

The Blast Furnace and Steel Plant

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TONNAGE

MAN has risen to the civilized state through devising and learning to use weapons and tools, and later, machines. His progress was at first very slow and continued to be slow until ways were discovered for producing articles of iron and steel. Rapid progress in material civilization came only after steel could be produced in large quantities. Thus steel is the supporting framework of the structure of modern life, and steel in large quantities is essential to the maintenance of this material progress.

However insistent may be the demand for special qualities and for refinements in manufacture, these must come hand in hand with increased production. There have been many false prophets who have decried tonnage as incompatible with quality, and many have been led away by the doctrine that nothing is good that is not produced slowly and by tedious methods. But the glory of this present day is that, through a better understanding of the arts, through ever improving equipment and through the courage of those engaged in the production of steel, quality in the highest degree accompanies the necessary increase in tonnage.

That from time to time the capacity for production exceeds the existing demand is an evidence of the comparative inefficiency of the financial and commercial factors in world progress.

Metallurgy and the Aircraft Engine

The Highest Standards for Materials and Treatments Are Set
by the Aeronautical Engineer—Aluminum Alloy, Some
Steel and a Little Bronze Make Up the Motor

By HENRY FISHBECK*

LITTLE does the layman realize the vast amount of research which has made possible the phenomenal flights of recent years. At the time of the World War, when the possibilities of aircraft were first realized to any great degree, the requirements were so urgent that there was no time for careful research. Since then, however, the aeronautical engineer has worked unceasingly to obtain the high standards of today. The results of his efforts are apparent.

The material, around which this article was composed, was secured at the plant of one of the foremost manufacturers of airplane engines; "Wasp" and "Hornet" engines are known wherever airplanes are found. The writer is in intimate contact with the production of these engines.

For example, during the war, a motor giving 70 hours service before the first overhaul was considered exceptional, while today 400 to 500 hours is not unusual. Also, design changes, evident to the casual observer, have made the engine more mechanically perfect, compact and light. With regard to weight, it is interesting to note that in 1916, 3 lbs. per hp. was considered good, while today the figure has been reduced to as little as 1½ lbs. per hp. These figures show that

*Metallurgist, Pratt & Whitney Aircraft Company.

the results of careful study have brought great benefit to aeronautics.

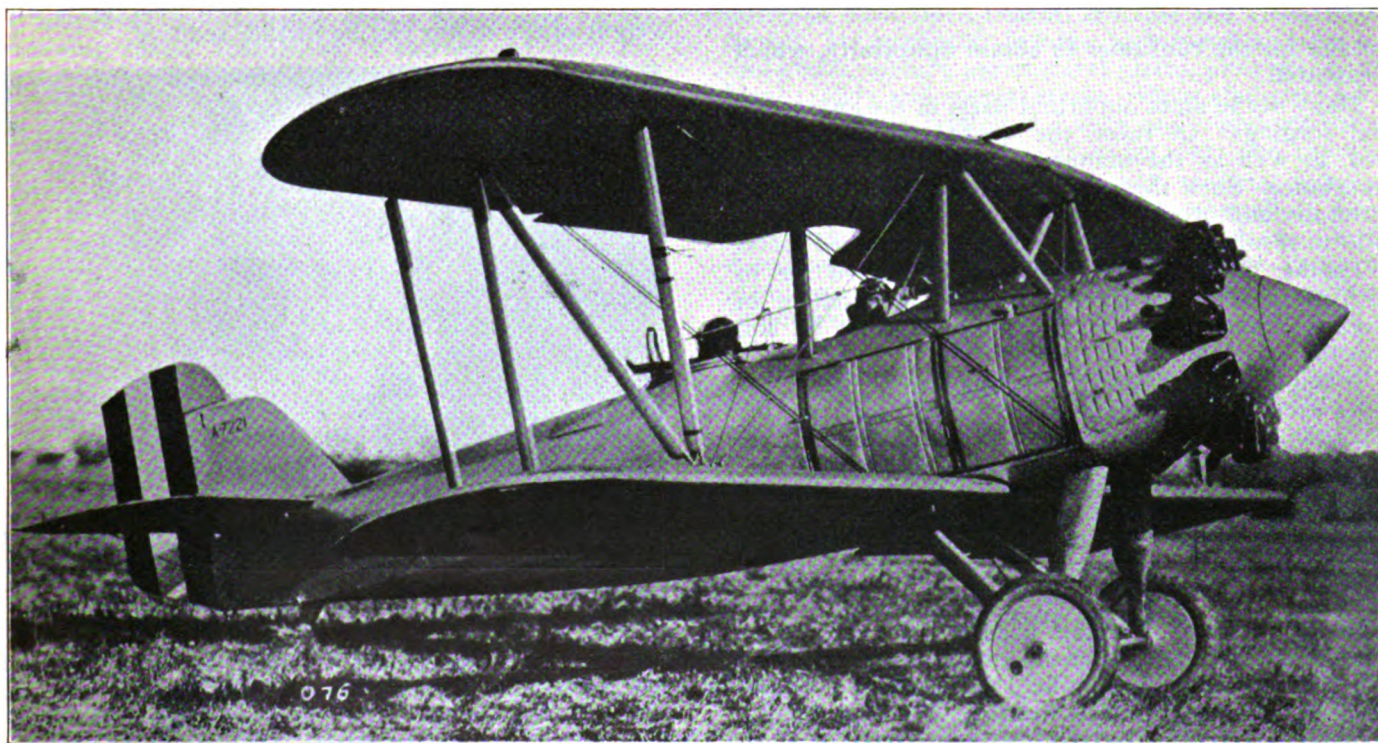
One field of study which is essential to the aircraft industry, especially in engine manufacture, is that of metallurgy. This brief article will attempt to describe in a general way the function of a metallurgical laboratory in the operations of a modern aircraft motor company. It might be well to begin with the problem of material specification.

Material Specification

The metals used in an aircraft engine are for the most part aluminum alloy and steel, with a small amount of bronze. Each piece of metal is purchased under rigid specifications which cover both physical and chemical properties. The specifications are written so as to give the mechanical engineer the physical properties of strength, hardness, resistance to fatigue, etc., which he desires in the final product. That this may be done, the metallurgist must see that the materials are in a condition to receive the proper handling. In this matter, the machinability of the metal is his chief concern.

It might be well to say that many of the non-ferrous alloys are treated before machining. Steels, on the other hand, must be soft enough to machine properly and then are subsequently treated to bring out the desired properties.

Again in regard to specifications, they must be of such a nature that the vendor is able to meet them

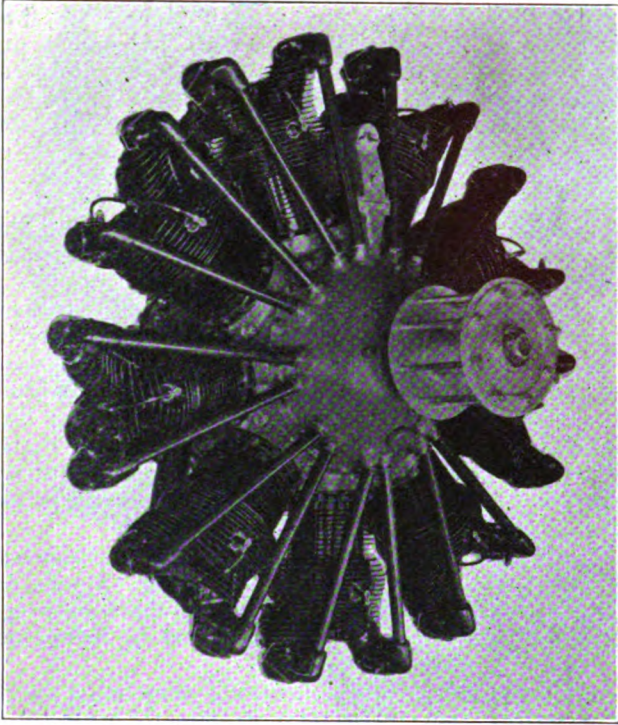


Vought "Corsair," Pratt & Whitney Wasp.

regularly and thus furnish uniform material from shipment to shipment. To gain this uniformity, it is always necessary for the purchasing department and metallurgist to work hand in hand.

Ferrous Alloys

The steels employed today are chemically the same as those used 10 years ago. The improvement in the physical phase lies in more advanced methods of melting, pouring, rolling mill routine, and bar annealing. This advance and control of general mill practice, as well as furnishing higher quality steels, also makes



Pratt & Whitney Wasp, 400-hp., 670 lbs.

it easier for the consumer to obtain uniformity, which is essential.

Many of the more important parts in the engine are steel forgings. In these the quality of the metals used, as well as the manner of forging, is of prime importance. Such things as the distribution of metal in the die and proper grain flow are necessary to get uniform results and give strength to the forged piece.

Further, most of the ferrous metals used are in the form of alloys. This is due to the fact that in an aircraft engine, the maximum strength must be had with the least amount of weight.

It might be of interest to enumerate a few of the alloys used. Among them are:

Medium carbon, chromium-vanadium	(S.A.E. 6150)
Medium carbon, chromium-nickel	(S.A.E. 3140)
Low carbon, nickel	(S.A.E. 2512)
Low carbon-chromium, nickel	(S.A.E. 3115)

Non-Ferrous Alloys

In the refining of metals used in the motor, perhaps the greatest advancement in the past decade has been made in the aluminum field. The advent of Dural has been a wonderful aid. Mention was made of the tremendous reduction in weight per hp. in the modern motor as compared with that of 1916 vintage. This

would not be possible had it not been for the development of these aluminum alloys. Along with this advancement came the forging of aluminum. Among

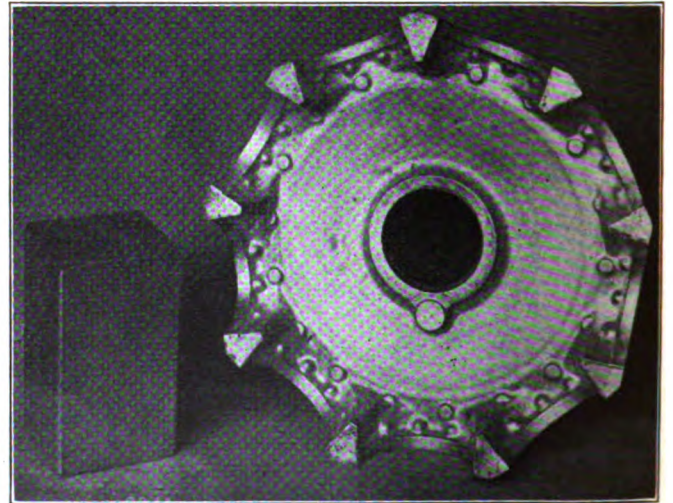


Steel forgings for aircraft engines.

the parts forged are gears, cam drums, crank cases and other parts which encounter more than ordinary strain. It is interesting to note that the largest aluminum forging made is used in the crank case of Pratt & Whitney aircraft engines.

Foundry practice in aluminum work must be carefully supervised. Careful molding and pouring are essential to produce the necessary quality of the metal. The average non-ferrous foundry could not successfully handle this work. Real up-to-date methods are required. Only the best of raw materials can be used. The metal must not be overheated in melting and must be cooled to the proper temperature, as measured with a pyrometer, before pouring.

There are disadvantages in any cast metal, due to the many variables encountered. The cooling properties of aluminum increase these disadvantages, and, consequently, this, plus the fact that aircraft engine parts are rigidly inspected, makes it imperative for the casting to be watched closely. The development of aluminum alloys has been remarkable but the field still offers many possibilities for further work. In view of this fact, it is not far fetched to predict that in the not too distant future, there will be aluminum alloys to take the place of many of the steel parts. As these materials enter the commercial field, the weight of the motor can be further reduced.



Aluminum crankcase forging, largest.

It is hardly necessary to make any comment on the bronze and white metals used for bearing surfaces. These have been developed by the automobile industry and have now reached a high point in quality manufacture.

There are two phases involved in the inspection of raw materials. The incoming stock is received in the rough inspection department. A lot number is assigned to each consignment. This number is used as reference through the process of manufacture. All important parts have the lot number stamped on the individual pieces being manufactured, so as to tie up as closely as possible the entire batch of material.

Raw Material Inspection

The initial inspection of forgings and castings is a mechanical one, which in addition includes visual inspection. Then a representative number of pieces are submitted to the laboratory for chemical and physical testing. In the case of steel bars, discs are cut from a representative number of bars and sent to the laboratory. The remainder of the bars in the shipment, as is the case in forgings and castings, are tested for Brinell hardness (or Rockwell in some cases). Some of the vital castings have coupons attached, which are also examined.

As has been said before, the tests in the laboratory are both chemical and physical. Included in these latter are those for hardness and tensile strength; also microscopical examinations and hot acid etching (macro testing). Sample gear blanks and other important forgings are quartered and subjected to the hot acid test. This will indicate how the forging was made and tell the story of grain flow.

After the material has been found to come within the specifications, the lot is released by the laboratory. The material is then placed in the rough stores department and is ready for use.

Heat Treatment

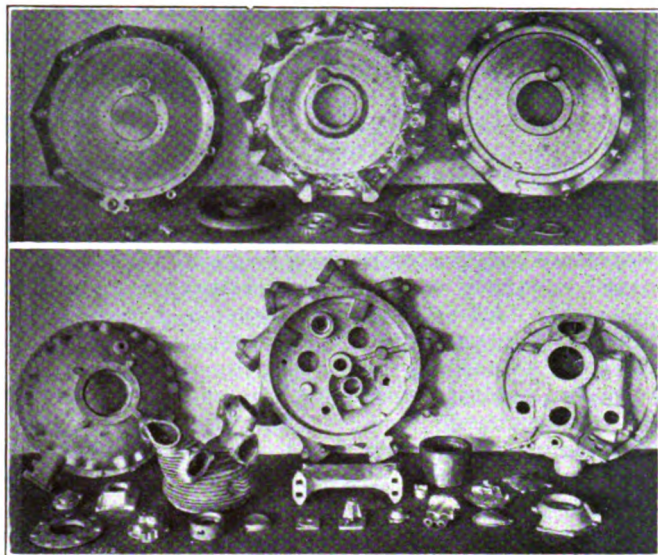
Perhaps the most important operation in connection with the manufacture of parts outside of mechanical accuracy is the heat treatment. It is in this operation that the physical properties are developed. To insure proper size and also make certain that all the necessary machining has been completed, all parts are inspected mechanically before being sent to the hardening room. Hardening is carried out with the most modern methods. Each part has a predetermined treatment to which reference is made by the foreman of the hardening department. This data indicates the proper handling, type of heating medium, depth of case desired, quench and draw, etc. Along with every batch of carburized work is placed a test piece for depth of case.

In connection with heat treatment, the advent of temperature control has been of great assistance. For example, the automatic controlled electrically heated lead bath and oven furnace allow for extremely close temperature control. This factor aids in keeping quality uniform from batch to batch.

After hardening, the parts are tested for hardness, using either the Rockwell or scleroscope testing machines, depending on the part and type of steel. A few parts from each batch are tested by the laboratory. If found satisfactory, the entire lot is inspected for hardness by the inspection department.

It is the hope of the writer to bring out the fact that there is nothing unusual in the handling of aircraft parts from a metallurgical standpoint. There is great similarity with that work in the automotive field. The main differences are that raw material inspection is more exacting, a better grade of materials is used and the thermal treatments are carried out under more

exacting conditions. The reasons for this are quite obvious since an automobile part can have a very liberal factor of safety without taking into account



Aluminum forgings (upper) and aluminum castings (lower), both rough and finished, for aircraft engines.

additional weight, while the aircraft part must have a greater factor of safety but be designed with minimum weight.

Tool Steel Merger

The Vanadium-Alloys Steel Company, Latrobe, Pa., has acquired the Colonial Steel Company, Colona, Pa., according to an announcement by Roy C. McKenna, president of the former company. Both companies make tool and high-speed steels.

The Colonial company, founded in 1901, has an annual capacity of 57,600 gross tons of ingots produced in basic open hearth, crucible and electric furnaces. Its products, besides high-speed and carbon tool steels, include agricultural plates, plow steel, saw blanks, alloy and special steels, copper clad steel bars, spring, cutlery, section and alloy and high-speed steel sheets and forged die blocks, rings, bars and shapes.

The Vanadium company has electric furnaces rated to produce 6500 tons of ingots annually. Alloy steel ingots, carbon and alloy tool steels and high-speed steels comprise its products. The company about two years ago acquired the Anchor Drawn Steel Company, Latrobe, and in this purchase secured a plant for making drill rods.

No changes in the management of the Colonial Steel Company are contemplated for the present, except that the sale of the products of the two companies will be co-ordinated. George P. Rhodes, T. Howe Childs and S. Clarke Reed will be the representatives of the Colonial company on the board of directors of the Vanadium company.

Cold-Drawn Steel Plant at Buffalo

A plant is to be erected immediately in Buffalo by Bliss & Laughlin, Inc., Chicago and Harvey, Ill. The Buffalo plant will be devoted to the same products as are now being manufactured at Harvey and have been since 1891.

The Use of Metallurgical Limestone*

Characteristics of the Stone Reviewed as They Affect Utilization—
Disadvantages Arising from Impurities—Behavior of
Magnesia in Slags—Size of Stone Desirable

By OLIVER BOWLES†

WHILE vast quantities of limestone and dolomite are used in metallurgy, the estimated production in 1926 being 23,860,000 tons, there are many problems connected with their use which have not received adequate study. The literature of metallurgy is notably lacking in comprehensive discussions of fluxing or furnace stone. Approximately 900 lb. of limestone is used for every long ton of pig iron produced in the blast furnace, but this important constituent of the charge receives little attention compared with the intensive study that has been applied to ores and fuels, the other important constituents of the charge.

In an effort to elucidate some of the doubtful points, the writer has made a wide review of metallurgical literature, and has had the disappointing experience of finding not more than a paragraph or two on metallurgical stone for each two or three thousand pages of literature reviewed. Furthermore, the limited information supplied is in some instances contradictory and even absurd. For example, a correspondent in a reputable metallurgical magazine classifies magnesia and silica together as impurities in flux "that must be melted and run off as slag."

From the furnace operator's viewpoint it is desirable that as complete knowledge as possible be obtained concerning the effects of chemical composition and physical character of the stone on its action in the furnace and on the quality of the metal produced. A better knowledge of these features is advantageous also to the quarry operator in that it enables him to work more intelligently in producing stone that will best satisfy the metallurgists' requirements.

The following pages comprise a brief compilation of data now available. Much of the information is well established and probably acceptable to most metallurgists. On some points there is room for debate, and the chief purpose in presenting a paper at this time is to arouse discussion which will throw more light on controversial points and thus assist the author in preparing a more comprehensive and accurate discussion of metallurgical limestone problems.

Blast-Furnace Flux

The chief impurities in most iron ores are silica and alumina, and the addition of a basic flux is necessary to form a slag. If iron ore were reduced without flux, the siliceous and argillaceous gangue would unite with the iron oxides to form double silicates of iron and alumina, which would involve a heavy loss of iron. With the addition of limestone, the silica and alumina have a stronger affinity for the lime and magnesia than they have for the iron, and in consequence double silicates of lime and alumina or magnesia and alumina are formed—compounds which contain very little

iron. Just as an acid and a base react to form a salt, so the siliceous impurities of the ore react with the basic flux to form a slag which corresponds to the salt of wet chemistry. Lime is infusible at the temperature of a blast furnace (but when it combines with the silica and alumina of the furnace charge it forms a liquid slag which floats on the molten iron.

At the fusion zone, approximately 15 per cent of the original iron exists as FeO , and this must be reduced in the lower part of the furnace. With insufficient flux a black slag containing iron is likely to be made during the reduction process. It is true, however, that a normal supply of lime will not in itself prevent loss of iron in the slag; other conditions must also be correct.

Coke is used as blast-furnace fuel, and when it burns varying amounts of ash are formed. The ash is composed largely of silica and alumina, which, like the similar impurities in the ore, must be removed. Therefore the formation of a slag with the ash is a secondary function of the limestone flux. The slag should pick up the coke ash in the combustion zone, for it is desirable to remove the ash which forms on the coke lumps in order that the coke surface shall be clean. Inasmuch as the combustion zone is the seat of life in a furnace, it is not only necessary to remove the ash but also to produce a slag which will pass freely through this part of the furnace. An improper slag adheres to the coke and is chilled by the blast. This results in a sluggish tuyere, and tuyere action must be carefully controlled by the furnace operator. The slag should have a melting point below the average tuyere temperature, and should be fluid enough to pour out readily through the cinder notch.

Another purpose of the flux is to remove sulphur from the metal. Most of the sulphur enters the furnace in the coke, but there is a transfer of sulphur from the coke to the sponge iron. Even when it has reached the bosh of the blast furnace, metal often contains twice as much sulphur as is permissible in the pig iron. Proper additions of flux with necessary temperature adjustments reduce the sulphur to specified limits.

In some localities, iron ores are associated with sufficient lime carbonate to be self-fluxing. Ores are said to be self-fluxing when the sum of the calcium and magnesium oxides is approximately equal to the sum of the silica and alumina. Such ores occur in the iron district of Birmingham, Ala. They smelt very readily, as the constituents are intimately mixed.

Action of Flux in the Furnace

When subjected to the heat of the furnace, the limestone in the charge is first converted to CaO (lime) and CO_2 (carbon dioxide). The lime reacts with the impurities to form slag. Precalcined lime is said to combine more readily with the impurities than the lime formed by calcination in the furnace, but the extra cost of precalcination probably more than off-

*Paper presented at the New York meeting of the American Institute of Mining and Metallurgical Engineers.

†Supervising engineer, Non-Metallic Minerals Experiment Station, U. S. Bureau of Mines.

sets this advantage. Calcination of CaCO_3 in the furnace is more economical than precalcination because usually there is sufficient available heat in the upper part of the furnace, and the heat used for calcination would otherwise be lost as sensible heat in the waste gases.

Alumina may be regarded either as an acid or a base, for it will combine with silica to form aluminum silicate, thus performing the office of a base, or it will unite with lime to form calcium aluminate, acting in this case in the capacity of an acid. In ordinary blast-furnace practice, silica and alumina (SiO_2 and Al_2O_3) are regarded as acids and the lime and magnesia (CaO and MgO) as bases. Feild and Royster¹ found that in general the effect of increasing the Al_2O_3 content of slags is to increase viscosity and melting temperatures, though under some conditions this may not be true. In general, therefore, the presence of excessive alumina in either flux or ore not only requires a correspondingly large amount of calcium or magnesium to neutralize it but also demands additional heat units to give the resulting slag the desired fluidity. On this account, the clay content of fluxing stone should be kept at a minimum.

Definite data on lime-alumina-silica compounds in the liquid phase of slags are not now available. It is generally assumed, however, that for efficient sulphur removal an excess of limestone should be added above that required to satisfy the demands of the silica and alumina present.

McCaffery and Oesterle² found that the effect of alumina was to increase the solubility of the slag for calcium sulphide, and to decrease its solubility for manganese sulphide; also, that temperature is a much more important factor than chemical composition in its effect on the sulphur solubility of the slag. Therefore, for the most effective reaction, a high temperature should be maintained, for at high temperatures the slag will more completely desulphurize iron than at low temperatures. This is probably due to increased rates of interchange between slag and metal at the higher temperature, more complete deoxidation of the slag at the higher temperature, and to the fact that a more basic slag can be carried. Sulphur and other impurities are best removed where the slag has a high fluidity.

Effects of Impurities on Fluxing Stone

The majority of blast furnaces employ about 900 lb. of flux for each long ton of pig iron produced. The amount of flux required varies with the amount and nature of the impurities in the ore and in the stone itself. The foreign elements in fluxing stone are usually the same as those in the ore for the removal of which the flux is added; namely, silica and alumina. It should be emphasized that impurities in the limestone are doubly detrimental; in the first place, their presence reduces the percentage of lime and magnesia in the stone, and in the second, they require a certain share of the lime and magnesia to flux them off, as the flux must neutralize its own impurities as well as those of the ore.

"Available carbonate" is a term applied to the percentage of calcium and magnesium carbonates available for fluxing the ore after a sufficient percentage has been deducted to neutralize the impurities in the stone itself. In the average blast-furnace slag the ratio of $\text{SiO}_2 + \text{Al}_2\text{O}_3$ to $\text{CaO} + \text{MgO}$ is about 1 to 1. Thus for every pound of silica and alumina present in

a high-calcium flux, 1 lb. of lime is required to flux it. A pound of lime (CaO) is derived from 1.785 lb. of limestone (CaCO_3); hence if there are 4 lb. of $\text{SiO}_2 + \text{Al}_2\text{O}_3$ in each 100 lb. of the stone, not only does the stone lose this 4 lb. of impurity, but also 4 by 1.785 lb. of pure limestone which is required to flux the impurity—that is, a total of 11.14 lb., and the "available" carbonate in each 100 lb. of stone is only 88.86 lb. This may be expressed in a general formula as follows: If A = the percentage of $\text{SiO}_2 + \text{Al}_2\text{O}_3$ in the stone, the available carbonate is $100 - A - 1.785A$, or $100 - 2.785A$. Where a dolomite is employed it requires about 1.914 lb. of stone to give 1 lb. of the combined oxides of calcium and magnesium. Hence for a dolomite flux the general formula for determination of available carbonate becomes $100 - 2.914A$. Most fluxing stone used in the United States runs under 10 per cent magnesium carbonate, and hence the conversion factor may be taken as 1.8 and the general formula as $100 - 2.8A$.

Another disadvantage in using impure stone is the formation of additional slag, which increases the fuel consumption. Extra slag requires extra coke but there is a difference of opinion as to how much extra coke is needed. As other conditions may affect the amount of coke required for each additional pound of slag formed, it is difficult to arrive at an actual figure for the additional fuel cost when an impure stone is used. If A = the sum of per cents of silica and alumina in the stone, the slag formed from these impurities will be approximately $2A$. If it is assumed that x lb. of coke are required for each pound of slag, the extra coke required to flux the impurities in the stone will be $2Ax$ lb. for each 100 lb. of stone. Hence, any blast-furnace operator who has determined a figure for the amount of coke required for each additional pound of slag formed can estimate closely the additional fuel expense caused by the use of impure stone. Assuming a value of y cents per ton for metallurgical coke, the extra cost of fuel on account of impurities in the stone will be

$$\frac{2Axy}{2000} \text{ or } \frac{Axy}{1000} \text{ cents}$$

for each 100 lb. of stone. For each ton of stone this will be

$$\frac{20Axy}{2000} \text{ or } \frac{Axy}{50} \text{ cents.}$$

A third source of loss due to impurities in the stone is reduced furnace output. Furnace output for a given ore is, in general, inversely proportional to coke consumption per unit of slag, and as the extra slag requires extra coke, furnace production may be cut down to some extent, though the exact amount is governed somewhat by the amount of wind blown. T. L. Joseph³ has found that for 50 furnaces investigated the number of pounds of coke burned per square foot of hearth area per minute varied from 2.5 to 5.5. If the same wind is blown and the fuel consumption goes up, the iron tonnage will decrease. There are, however, no definite standards for rates of blowing. If a furnace were blown a little faster to compensate for and increase in fuel consumption arising from the use of low-grade stone, the furnace output might not suffer any reduction. If unusually impure stone were used, the output might be reduced.

If V = the price in cents of pure stone per ton, and V' = the price of impure stone, disregarding the pos-

sible reduction in furnace output and combining the two chief sources of loss—namely, the reduction in available carbonate and the extra fuel required,

$$V' = V(1 - 0.028A) - \frac{Axy}{50}$$

By substituting any given values for percentages of impurities, pounds of coke per pound of slag, and value of coke per ton, a fairly definite figure may be obtained for the value of an impure stone as compared with a pure stone. If the value of an impure stone as thus calculated is lower than the actual cost at which such stone may be delivered at the furnace, it would be more profitable to use the higher priced pure stone. Maccoun⁴ states that each decrease of 1 per cent SiO_2 between 5 per cent and 1 per cent amounts to a reduction in cost of approximately 10 cents per ton of limestone, because it saves coke, increases production, and lowers operating cost.

Other impurities in the stone are sulphur and phosphorus, but usually they are present in amounts so small as to be negligible. A sulphur content of less than 0.1 per cent does no harm, and it is unusual to find more than this amount in commercial limestone. Hall⁵ states that for 110 analyses of Pennsylvania limestones given in State College reports of 1899 and 1900, the average sulphur content was only 0.08 per cent, while in 163 analyses sulphur was ignored because there was so small an amount. Phosphorus is usually deleterious only where the flux is used in the manufacture of Bessemer iron. For this purpose the phosphorus content should be as low as possible, and should not exceed 0.01 per cent. For other grades of iron the phosphorus content may reach 0.1 per cent without harmful results, and a content as high as this is exceedingly rare.

Slagging Effect of Magnesia

The effect of magnesia in fluxing stone is an unsettled question. Some blast-furnace men are opposed to its use while others use it successfully. Dolomite is widely used as a blast-furnace flux in England. If it is assumed that all the magnesia unites with silica to form MgSiO_3 , and all the lime unites with silica to form CaSiO_3 , it would appear that magnesia is the better fluxing agent, for 1 lb. of MgO will convert 1.51 lb. of SiO_2 into MgSiO_3 , and 1 lb. of CaO will convert 1.08 lb. of SiO_2 into CaSiO_3 . It is probably on this basis that Forsythe⁶ makes the statement: " MgO has a fluxing power 1.4 times that of CaO ." This is not a safe assumption, however, for other compounds are also formed, such as dicalcium and tricalcium silicates, also calcium and magnesium aluminates. Much is still to be learned concerning the proportion of such compounds formed under varying conditions, and the effect on slag viscosity of the various possible compounds.

As the result of some recent valuable research, McCaffery and Oesterle⁷ claim that MgO cannot be added in an amount corresponding to the chemical equivalent of CaO , for with the addition of MgO some magnesian minerals, such as pyroxene, forsterite or akermanite are formed, and the physical characters of these minerals may differ greatly from those of the calcium minerals such as anorthite or calcium bisilicate, which might otherwise be present. A slag consists almost entirely of compounds of the primary components (CaO , MgO , Al_2O_3 , SiO_2) and it is really the

variation of the properties of these compounds that changes the properties of the slag. The authors found that 18 compounds of the four primary components may be present. In discussing McCaffery and Oesterle's paper, B. E. Pheneger said that magnesia should be added to give increased fluidity; also, that 19 operators in Lake ores agreed that their practice is adversely affected if the magnesia content of the slag exceeds 6 per cent. In what way it is adversely affected is not clear, but one would infer from the context that improper sulphur removal is the chief objection. Reference is made to the fact that at times high-magnesia slags become less fusible and exhibit increased viscosity.

In further discussion of the paper, G. M. Hohl does not agree that 3 to 5 per cent MgO in the slag should be the limit for good practice, for at Bethlehem the slags average 17 to 19 per cent MgO and the sulphur content and the coke consumption are no higher than at plants using low-magnesia stone. Carnegie⁸ says that for blast-furnace flux "the presence of a large quantity of carbonate of magnesia in the limestone increases the quantity required per ton of iron produced, and in consequence the cost is greater." Such a statement conflicts with the claim that MgO has a greater fluxing power than CaO . From the information now available, it would appear that lime and magnesia are about equally effective for the removal of silica and alumina.

Magnesia as a Sulphur Remover

Magnesia is generally regarded as less efficient than lime as a sulphur remover, but here also there is a difference of opinion. Johnson⁹ refers to Sir Lothian Bell's opinion that magnesia is inert as a sulphur remover, but makes the definite statement that in his opinion magnesia is just about as efficient as lime. It is probable that very few metallurgists will agree with this statement.

One author, in referring to the preference for dolomite at Alabama furnaces, went so far as to conclude that the magnesia must be a better desulphurizing agent than lime, but the real reason why dolomite is preferred at the Alabama furnaces in question is not because of any preference for magnesia, but because the dolomite has a lower silica content (1.25 per cent as against 3.5 per cent in the high-calcium stone), and also because of a greater uniformity in the composition of the dolomite.

Effect of Magnesia on Slag Viscosity

Much difference of opinion seems to exist as to the effect of magnesia on the viscosity of slags. In a number of tests covering the smelting of various metals, the statement is made that magnesia tends to make the slag ropy and viscous; in fact, it is mentioned so frequently by practical operators that it seems to be established as a fact in many instances. This conclusion, however, would seem to conflict with theory. It is a well established principle that a silicate with more than one base fuses at a temperature lower than a one-base silicate. Johnson¹⁰ states that "the addition of a certain amount of magnesia has a marked effect in lowering the fusion temperature of the slag." He refers to the experiments of the Swedish investigator, Akerman, who found that the most fusible slag consisted of two parts lime to one part magnesia. Morgan¹¹ says "the presence of much magnesia in the stone tends to make the resulting slag less refractory." Maccoun¹² claims that for spiegel and ferromanganese

a mixture of one-half calcite and one-half dolomite is preferable to a high-calcium flux, as it "gives a more fluid cinder, permits a more basic slag, and thus keeps manganese loss low."

On the other hand, Hofman¹³ regards magnesia as undesirable in a lead furnace, as it makes a pasty slag. Gowland¹⁴ states that magnesia is objectionable, giving pasty slags in both lead and copper smelting.

Herty¹⁵ believes that high-magnesia (open-hearth) slags are almost always viscous and require an undue amount of working with fluorspar or some other "thin-ning" agent.

Feild and Royster¹⁶ found that the temperature viscosity relations of an iron blast-furnace slag were practically unaffected by the presence of magnesia up to 14 per cent, but no statement is made regarding higher percentages of magnesia.

The seeming conflict is possibly explained by the fact that slags consist of quite a number of components combined in complex ways in consequence of which it is very difficult to determine just what result would ensue from increasing a single component. This seems to be the conclusion reached by Feild and Royster, as they say: "The most important conclusion to be drawn from the results of the investigation is that a slag, even when melted and completely converted into a liquid, is composed of relatively complex compounds of lime, alumina and silica, and not of a simple mixture or solution of the constituent oxides CaO , Al_2O_3 , and SiO_2 . The temperature-viscosity relation of the slag is not therefore . . . changed continuously and in the same general direction by the gradual addition of a single constituent." It seems possible, therefore, that under some conditions an increase in the magnesia content may result in a more viscous slag, and under other conditions in a more liquid slag.

It is possible that the amount of alumina present may greatly affect the viscosity. Forsythe¹⁷ makes a significant statement in this connection, as follows. "With tolerably pure silicate slags having less than 5 per cent Al_2O_3 , the proportion of MgO need be of little concern, since successful slags have been run with CaO as low as 12 per cent. Al_2O_3 exceeds 10 per cent, however, MgO in excess of 20 per cent causes too much viscosity in the cinder whereby it becomes sticky and does not work freely."

Confusion may result also from the use of the terms "melting point" and "free-running temperature," for these may differ widely. Some slags have a short range of viscosity while in others it is long. The former may be compared with ice, the latter with tar. The formation temperature of a slag bears no definite relation to its flowing temperature. From the standpoint of slag viscosity, the free-running temperature is of more importance than the melting point.

As a rule, high-calcium fluxes are preferred, but the difference in action between the high calcium and the dolomite fluxes is so small that usually the choice is governed by other factors, such as availability, cost, or percentage of impurities.

Effect of Magnesia on Slag Utilization

Where crushed or granulated slag is used for concrete aggregate or road building, as a substitute for crushed stone, the magnesia content is not generally regarded as important. However, in a recent communication from a company producing very large

quantities of fluxing stone, the statement is made that some blast-furnace operators are requesting stone with 7 to 10 per cent magnesia because the resulting slag is more desirable for roadmaking. The advantage is probably due to the decreased slaking effect in the high-magnesia slags.

Slag is now used extensively for the manufacture of Portland cement. For this, the flux must provide a slag having a magnesia content within the fairly narrow limits demanded by cement specifications.

Factors Governing Use of Impure Fluxing Stone

The cost of stone delivered at the furnace commonly has a very direct bearing on the quality of stone used. This is due to the fact that an inferior stone may be used if the price is low enough. The question of quality is so intimately related to cost that the problem of purity of blast-furnace flux becomes quite complex. In order to clarify this point, it is necessary to make a distinction between impurities. In general, they fall in two classes. Some, such as sulphur and phosphorus, are detrimental to the quality of the iron produced, hence the use of stone containing excessive quantities of these impurities could not be justified, no matter how low the price.

The other more common and abundant impurities are silica and alumina, which are not regarded as detrimental to the iron, their chief disadvantages, as pointed out, being the requirement of additional limestone and coke to convert them into slag. Suppose that a relatively pure stone and an impure stone are both available, and that the impurities are of the silica-alumina type, which has no detrimental effect on the iron. If the price of the impure stone is low enough to overcome the disadvantages, the impure stone may be used in preference to the pure stone. Thus at Bethlehem, Pa., a stone quarried near the furnaces, running as high as 5 per cent silica, is used extensively in preference to the low-silica stone from McAfee, N. J., because the transportation charge from McAfee is greater than the total cost of quarrying the impure stone. The quality of the ore also influences the degree of impurity permissible in the flux. Thus it would not be wise to use a flux high in silica with a high-silica ore.

It is evident from the above that no definite rules can be laid down regarding the purity of a stone that may be used for flux. A stone that might be condemned in one locality might be quite acceptable in another where the conditions were different. The direct bearing of cost on use indicates how important it is to be able to calculate even approximately the relation between percentage of impurities and price. Usually the use of an impure stone can be justified only where it has the advantage of close proximity to the furnace, thus eliminating the usually heavy item of transportation expense.

Size of Stone for Blast-furnace Flux

Fluxing stone is used in a great variety of sizes. At some furnaces the crusher run is used directly without screening. Usually the fines below $\frac{1}{2}$ in. are taken out, partly because they tend to retard the draft and partly because they usually contain more impurity than the lump stone, as sand and clay segregate in the fines. In modern quarry practice, and particularly in underground mining, there is less impurity mixed with the stone than during former years under cruder practice; therefore, on the basis of purity, fine mate-

rials may not be detrimental. A common range in size is $4\frac{1}{2}$ in. + $\frac{1}{2}$ in., though larger sizes are often used.

It is probable that the finer sizes are less detrimental than the demands would seem to indicate. In the course of visiting quarries the writer has observed that furnace operators using stone produced at their own quarries manage to utilize much smaller sizes than are usually demanded where stone is purchased from independent quarry operators.

Regarding the upper limit of size, Maccoun¹⁸ claims that all stone should pass through a 6-in. ring, as larger lumps may go unburned even to the tuyere, wasting heat, and injuring the furnace lining by corrosion. Blast-furnace troubles have been attributed in some instances to irregularities in size of the limestone. In general, it may be said that uniform sizing improves the working of the furnace.

Basic Open-Hearth Flux

The open-hearth process of making steel consists in melting pig iron and steel or iron scrap, and boiling the mixture generally with the addition of some very pure lump iron ore, until the carbon is reduced to the desired amount. A flux is added to the charge in the furnace mainly for the removal of phosphorus and sulphur. For a phosphorus content in pig iron not exceeding 0.25 per cent, additions of 6 to 12 per cent limestone are considered good practice. When a pig iron with a higher phosphorus content is used, as much as 17 per cent limestone may be charged. The phosphorus is oxidized to phosphoric acid, which unites with the lime to form calcium phosphate. The ability of a slag to take up phosphorus depends both on basicity and fluidity.

Fluorspar (CaF_2) is added because it increases the fluidity without decreasing the basicity. It is possible, however, to have the slag too fluid, for it then becomes active in attacking the dolomite lining. The more basic the slag, the higher its melting point; hence, the higher its temperature, the more lime it can absorb. An excessively high temperature is also destructive to the basic lining, as it may approach the softening point of the lining.

Choice between Limestone and Lime

Either lime or limestone may be used. When the flux is added in carbonate form the evolution of CO_2 makes the bath boil, insuring a lively reaction. Extra heat is required for calcination, but evidently no more than would be required for precalcination. Herby¹⁹ says that at some basic open-hearth furnaces flux charges consist of both limestone and lime, either as original charges of both or as a primary charge of limestone with subsequent additions of lime when it is found necessary to increase the CaO content of the slag. In some instances, the entire flux charge is of lime. This author claims that where lime is used the hot-metal (pig iron) content of the charge may be reduced, and thus the speed of the furnace may be increased.

It is stated by Baker²⁰ that the Dominion Iron Works, Sydney, N. S., uses lime made from a marble running less than 1 per cent SiO_2 , purified gas being used in calcining to keep down the sulphur content. Lime is used in place of limestone to reduce the time of heats. The Granite City Steel Works²¹ of the National Enameling & Stamping Company, at Granite City, Ill., has two rotary kilns each 8 by 110 ft., to

burn lime for open-hearth furnaces. Evidently this company prefers burnt lime to limestone. Hamilton²² states that from a metallurgical standpoint limestone is preferable, but from an economic standpoint lime has certain advantages. He claims that furnace output may be increased about 20 per cent when lime is substituted for limestone.

Effect of Impurities in Flux

In blast-furnace slag the proportion of $\text{CaO} + \text{MgO}$ to $\text{SiO}_2 + \text{Al}_2\text{O}_3$ is about 1 to 1, but with basic open-hearth slag this ratio is about 2.5 to 1. Hence if A equals the sum of per cents of SiO_2 and Al_2O_3 in the fluxing stone, the bases ($\text{CaO} + \text{MgO}$) necessary to form a slag with these impurities will be $2.5A$, and the carbonates required will be $1.8 \times 2.5A$. The formula for determination of available carbonate is therefore $100 - (1.8 \times 2.5A - A)$, or $100 - 5.5A$. In comparing this with the general formula for available carbonate in blast-furnace flux, which reads $100 - 2.8A$, it is evident that impurities are much more detrimental in open-hearth than in blast-furnace flux. Thus a limestone with 2 per cent impurity when used as blast-furnace flux would have an available carbonate content of 94.4 per cent, while if used for basic open-hearth flux it would have only 89.0 per cent available carbonate. On this account specifications for open-hearth flux usually demand a limestone with a silica content not to exceed 1 per cent, and an alumina content not exceeding 1.5 per cent.

As the chief office of basic open-hearth flux is the removal of phosphorus, and as magnesium has a lower affinity than calcium for this element, dolomites or magnesian limestones are undesirable. The maximum permissible content of MgO is usually fixed at 5 per cent. The effect of magnesia on slag viscosity has already been discussed.

Size of Flux Stone

Great variation has been observed in the size of fragments. Some operators will take nothing under 5 in.; others use stone between 2 and 12 in. in size. Usually fines are excluded more rigidly by open-hearth operators than by blast-furnace men.

Rate of Liquefaction of Flux

Limestones vary greatly in the rate at which the lumps are assimilated and become completely liquefied in the slag. Fragments of most well consolidated limestones retain their original shapes, and are more or less firm and solid after complete calcination. Lime burners desire stone of this quality because it gives a high percentage of lump lime. Therefore, after the limestone lumps in an open-hearth furnace are completely calcined, they may still retain their original shapes. Limestones vary greatly in the rate at which such masses of lime dissolve or melt in the slag. This characteristic of the flux has a definite bearing on the proper size of fragments. Obviously if large masses of a slowly assimilated stone are used furnace operation will be retarded.

A loosely consolidated limestone that would completely disintegrate during the process of calcination would have the advantage of very rapid assimilation in the slag, but on the other hand such a stone would give excessive fines during the process of quarrying and crushing. It would appear that the furnace should not be supplied with large fragments of stone that is

(Continued on page 1321)

Sheet Steel for Automobile Bodies

The Common Surface Defects Which Impair or Destroy the Usefulness of Sheets Are Described and Illustrated—Causes of Faulty Surface Are Discussed and Remedies Outlined

"AUTOSHEET"
PART VIII

THE surface inspection of sheet steel after it has been completely processed, is probably one of the most exacting tests applied to any product of the steel industry today. The Duco and enamel finishes as well as nickel, cadmium and chrome plating applied to these sheets after they have been drawn to the shape intended, produce a high luster and it can readily be imagined that even the slightest surface

The subject matter of this article appears here somewhat out of its turn, having been advanced in the series which will resume regular sequence hereafter. The series when finished will be published in book form.

defect, if not causing a localized fracture and breakage, will, after being painted or plated, magnify this same defect. This magnified defect will then have to be buffed or sand papered at an additional cost to the finishing departments. For this reason automobile

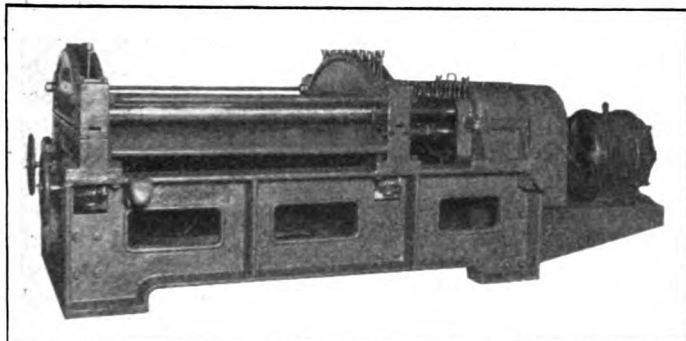


FIG. 1—Roller leveler for sheets.

body manufacturers demand of the sheet mills as many first class sheets as possible on their orders.

The general classification of sheets are "primes," "seconds" and "wasters." "Prime" sheets are those sheets which have a surface suitable for the body part intended. As a general rule the best side of the sheet is stamped with the manufacturer's name or trade mark accompanied by some other mark that will identify its process in case of excessive breakage or an excellent showing. Sheets on which both sides have had defects are thrown to one side as "seconds." For the most part the majority of surface defects, especially from the hot mills, are such that they run through the sheet and are perceptible from both sides. With a knowledge of what the blanked outline of the sheet will be before it is stamped the inspector can reinspect these seconds, passing sheets whose defects will not affect the appearance of the finished stamping. Second sheets, not passable, under the above conditions, together with the top and bottom sheets of the pile which are usually badly stained, are classified as "wasters."

Assuming at this point that the sheets have been processed to the satisfaction of the metallurgical department and that any or all physical tests which may have been taken show them to be passable, we are now ready to pass judgment on their surface.

Roller Leveling and Oiling

The pile of sheets to be inspected is placed on a bench under powerful overhead lights which by direct lighting brings into relief most of the defects. Quick eyed inspectors, long experienced in noting defects, watch these sheets as they pass one by one into the roller leveler. This roller leveler, as shown in Fig. 1, consists of two lines of rolls; one set above the other and so adjusted that as the sheet passes between these two lines of rolls it is forced up and down in a buckling motion. This motion serves to flatten out the sheets and erase any depressions or elevations that they might have assumed in their processing through the mill.

Most automobile sheets are coated with light paraffin oil to protect them from rusting during transit. To accomplish this with a minimum amount of effort two felt rolls saturated with this oil are attached to the exit end of the roller leveler which oils the sheets as they come through to the piling end. Here the number of primes are usually counted by an automatic counting machine.

The draft for roller leveling can be light or heavy depending on the shape of the sheets when they reach the inspection department. If the sheet is quite flat only a light leveling is necessary. If sheets show a tendency to stretcher strain the rolls will be set for a heavy draft as it has been found that this will temporarily relieve this condition. By temporarily we mean possibly a week or 10 days, depending on the gage of the sheet and the amount of leveling draft it received.

While it is general practice for the inspection department to maintain men at the bar mill, hot mill, cold rolling and pickling departments to inspect and throw out sheets which would eventually be discarded, a great many defective sheets reach the final inspection, as might be imagined. The nature of the defects are varied and any one defect which we outline below is caused from several factors, not all of which will be explained herein.

However, it is our purpose to illustrate and describe the major defects, their probable cause and remedy. Such defects seldom pass the vigilance of these inspectors and as a result a great many of these defects are seldom encountered at the automobile plants. However, to err is human and occasionally some of these defects get by and are found in so called "prime" sheets with which the consumer does the best he can, charging back excessive work if the defect is very noticeable in the sheet.

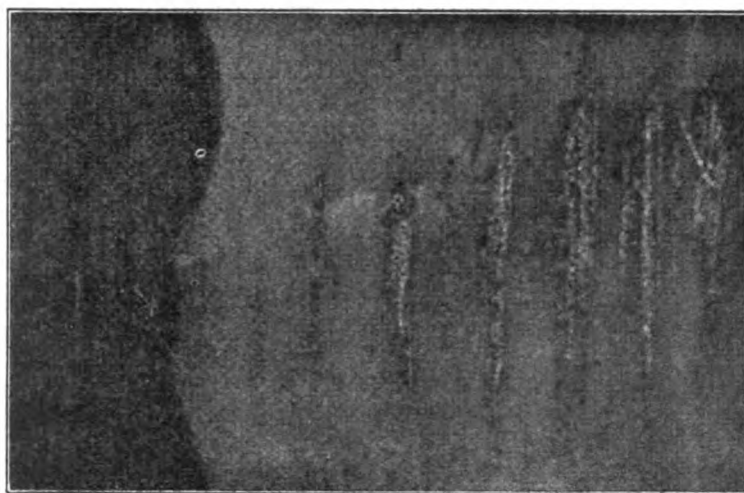


FIG. 2—Open-hearth seams running parallel to direction of hot rolling. Note annealing oxide on side of sheet.

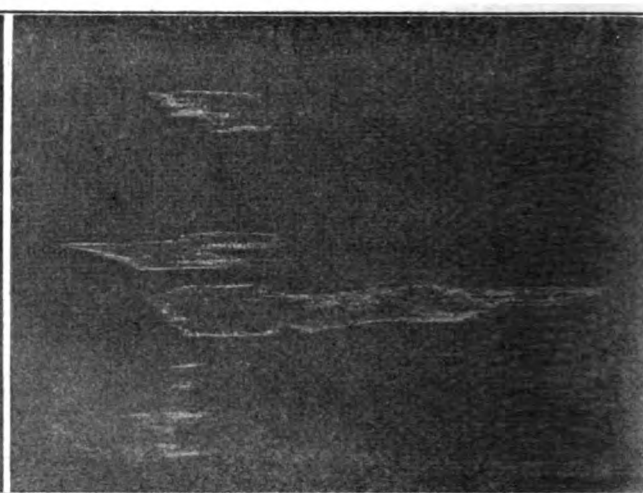


FIG. 3—Open-hearth scabs slightly elongated in the direction of final rolling.

A great many defects are not discernable as the sheets are inspected, but only after they have been stamped to form do they manifest themselves. Thus a sheet containing minute pits such as small normalizing pits may pass inspection, but the stamping operation tends to increase the size of these pits and if the part carries a nickel or chrome plating the defect is so pronounced as to now cause its rejection.

The majority of surface defects can be traced to the open hearth and hot mills with particular emphasis on the latter. Hot mill defects are traceable directly to the mechanical methods by which sheet bar and breakdown sheets are hot rolled to breakdowns and finished black sheets respectively. The deeper one goes into this question of rectifying hot mill defects the more one realizes how much of the human element enters into the manufacture of sheets—perhaps more than any other steel product. For example, certain hot mill defects can be rectified by raising and lowering the temperature of the rolls. This is a delicate procedure as the temperature change is recorded in the color change of the roll and usually is very slight. Under such conditions we might be led to wonder what the results would be if the roller who is to judge this color-temperature change has poor eyesight—or color blindness.

Open Hearth Defects

The first defects perceptible in finished sheets are open hearth defects which are usually seams, scabs and blisters. Fig. 2 illustrates the average appearance of "seams." The dark border on the left side indicates the blue oxide border formed in annealing and averages about one and a quarter inches in width for this particular example. The seams which are formed at right angles to the wall of the mold now run parallel to the side of the sheet and also parallel to the direction of final hot rolling. These seams are the result of gases in the molten steel not being able to escape as the steel solidified.

Inasmuch as the crystallization is very rapid from the wall of the mold toward the center of the ingot, the gases are entrapped and fall in line with the dendritic formation which is very pronounced in the direction of right angles to the mold. In reheating the ingot in the soaking pits a great many of these seams are exposed and are oxidized. When the ingot is rolled

to such thin sections as sheets this defect becomes very pronounced. In Fig. 2 these seams are about one-eighth of an inch wide and about one-half an inch apart, with a deeply pitted and oxidized surface. Open hearth heats of stabilizing chemical analysis together with a close watch of the temperature at which the steel is poured will help to overcome this defect. Open hearth seams however are very hard to constantly and consistently control and the fact that they are so pronounced in sheet products induces manufacturers of sheet bar to work toward the elimination of this defect as much, if not more, than any other defect which will be subsequently encountered.

"Scabs" are best illustrated in Fig. 3 and are seen as sliver-like spots slightly elongated in the direction of rolling. The largest scab present runs through the center of the photograph and is about $\frac{3}{8}$ -in. wide by 5 in. long with the size of the other scabs in proportion. Scabs are usually caused by a splashing of the steel, as it is teemed into the molds. This scab adheres to the ingot and usually shows up in a slivered condition in the sheet bar or breakdown and is discarded. Careful teeming or pouring should overcome this defect.

Blisters (not illustrated), are gas pockets lying just below the surface of the sheet which, under certain conditions of temperature or pressure or both, will cause the expansion of the gas within this cavity and subsequently the expansion of the metal above it which makes its surface appear analogous to a portion of a round smooth rock protruding slightly above the surface of water. This expanded section is not always round but will follow the shape of the cavity beneath it. If such gas cavities do not appear in the hot rolling the action of pickling will often cause a similar defect wherein the acid has penetrated to this cavity and with the temperature of the pickling solution and the action of the acid causes its expansion.

While a close examination of blisters will disclose whether caused by pickling or at the open hearth, the fact remains that it is primarily open hearth practice which is to blame. Teeming at as low a temperature as possible and keeping gases at a minimum so as not to have a "wild" pour will help eliminate this factor.

The next noteworthy defect to be brought to our attention as the steel progresses along through the

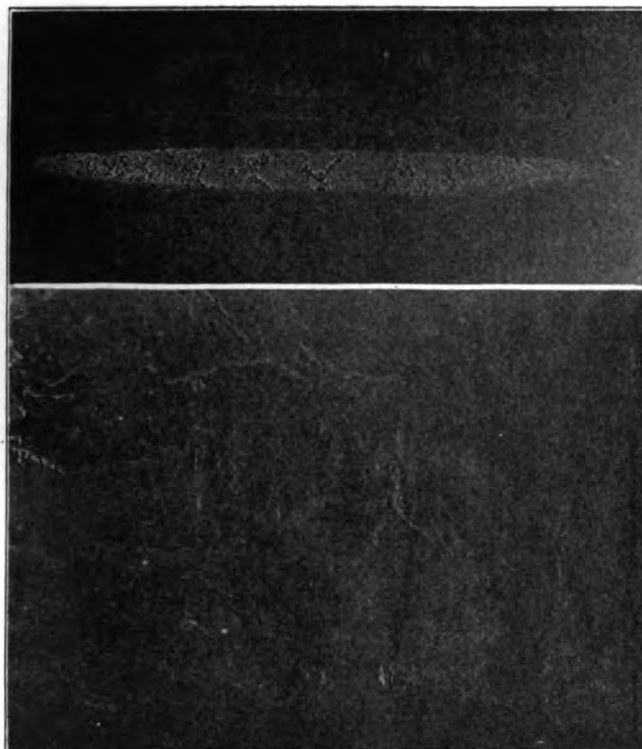


FIG. 4 (upper)—Blooming mill scale, length parallel to direction of final rolling. Note its deep inclusion within the finished sheet.

FIG. 6 (lower)—Crop end sheet. Note short seams and scabs over the entire surface.

mill is "blooming mill scale" as illustrated in Fig. 4. This is caused by sections of the scale, formed in the soaking pits, adhering to the surface of the ingot in spite of the fact that water under high pressure is forced against it as it enters the blooming mill. As a general rule this water will remove pit scale but occasionally the heat of the soaking pits has been such that sections of scale are firmly imbedded and usually, from that point on, the scale is there to stay. Fig. 4 shows this scale in a sheet after it has passed through its designated processing. It can be clearly noted how hot rolling has elongated this defect. The scale is so deeply embedded that the cold rolling of the sheet did not so much as touch its surface. Note the deep scale pits. This scaled section is about $\frac{7}{8}$ in. wide in the middle and about 13 in. long and runs parallel to the side of the finished sheet. The only remedy for this defect is to remove all soaking pit scale, if possible, before the ingot is reduced in the blooming mill.

"Seams," which show up after the bloom has been rolled down to a sheet bar size, are best illustrated in Fig. 5. This photograph was taken from a finished sheet selected at the bar mill from a crop end of an ingot whose surface showed bad seams. These seams in the finished sheet are thin as if traced with a white pencil. They run parallel to the side of the sheet and are more or less parallel to each other.

Speaking of crop ends, we are now at a point where the sheet bar is to be cut to specified length, previous to which sufficient steel should be cropped. "Crop ends" are discarded and returned to the open hearth for remelting. This crop includes the tops and bottoms of ingots which contain a considerable amount of seams and especially "pipe" or that portion rich in

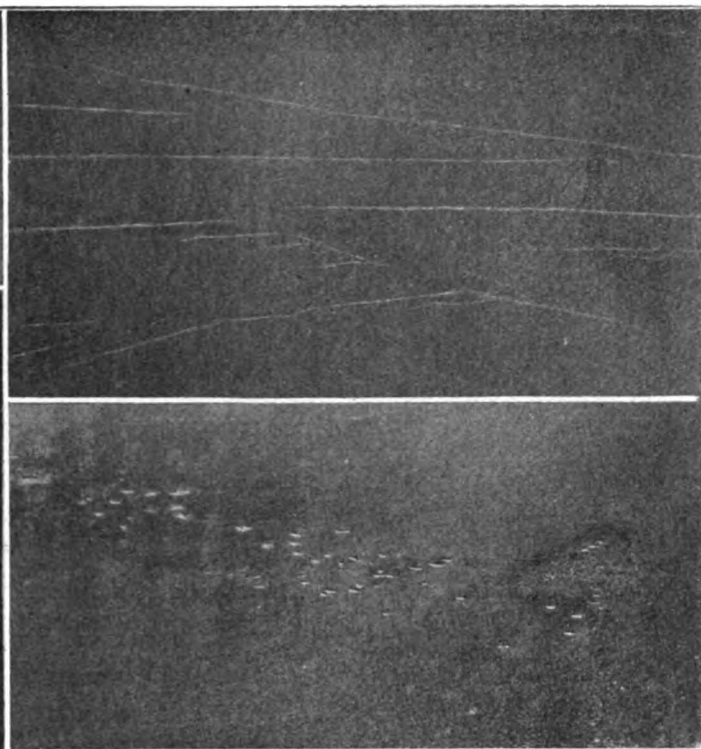


FIG. 5 (upper)—Bar mill seams, thin pencil like lines running almost parallel to direction of rolling.

FIG. 7 (lower)—Sheet furnace dirt. Top of photo is parallel to final rolling. Note elongation and depth of pits.

chemical impurities such as sulphides and phosphides last to solidify.

In view of the fact that the mill desires a maximum tonnage output and minimum scrap losses it can well be imagined that sheet bars are sometimes cut from what should have been cropped and discarded. As a result these particular sheet bars and subsequent sheets are poor in drawing properties due to excessive sulphides and phosphides present as well as full of seams and scabs illustrated in Figs. 5 and 6. In Fig. 6 note the scabs and short seams that literally cover its entire surface. The area of the finished sheet shown in this photograph is 8 in. x 12 in. The remedy for this defect is sufficient cropping from the top and bottom of the ingots to eliminate the major portion of the "pipe" and seams.

Defects Arising in the Mills

We now reach the hot mill where the majority of surface defects are usually made. Among the most pronounced and most common defects we find, floggers, pinchers, polishing scratches, hot mill g ease and sheet furnace dirt. These defects and their cause have been fully discussed in a previous issue of this magazine and so will only be briefly explained at this point.

The first hot mill defect will be illustrated under Fig. 8, which is known as a "flopper." This defect usually is formed in a hollow pack of breakdown sheets running through finishing rolls which are "full" or slightly convex in shape. As a result these full rolls give more pressure to a pack already heavy in the center with the result that the tail end of the pack is flopping up and down as it enters the rolls. This flopping motion causes the formation of ridges, running from slightly concave to parallel in shape, on the tail



FIG. 8 (upper)—Hot mill flopper, top parallel to side of sheet.
Ridge or spine approximately $\frac{1}{4}$ -in. wide.

FIG. 9 (lower)—Hot mill pincher running close to side of sheet (top).



FIG. 10—Hot mill pincher differing from that of Fig. 9, in that it appears on end of pack last to enter rolls. End of pack to the right. Note annealing scale.

end of the sheet. In Fig. 8 the ridges are slightly concave, the distance between the ridges being approximately 1 ft. and the overall length of the ridge 18 in. These floppers run through the middle of the sheet with the ends of the ridges pointing back toward the tail end of the pack.

The prevention of this defect in this particular case would be to turn steam on the rolls and reduce their convex shape and let the hollow packs continue. On the other hand full packs wherein the center of the pack is not as thick as its sides could be used with the shape of the rolls remaining unchanged.

In the reheating of breakdown sheets, in sheet furnaces, the sheets often collect dirt especially if powdered coal is used. This dirt, unless brushed from the surface of the sheets, will become embedded in the steel as it is rolled to finish size. After this sheet is pickled the dirt will be removed but will leave deep pits. This is fairly well illustrated in Fig. 7 and shows how, after the dirt was embedded, the sheet was pulled still further thus elongating the pits. The top edge of the photo runs parallel to the direction of rolling. Note the large patch of embedded dirt to the right which actually is about 2 in. x 3 in. in area. Some of the pits in line with this bad patch are as much as one-eighth of an inch in depth. It is not always possible to eliminate all of the dirt as brushing takes off only that which is on the outside of the pack. Periodical cleaning of sheet furnaces and the use of oil or gas as a fuel are the best remedies.

Hot Mill Pinchers

Figs. 9 and 10 illustrate very clearly two types of hot mill "pinchers." Pinchers are caused by several factors principally among which are:

- 1—A full pack of sheets on a hollow or concave roll.
- 2—An off and on gripping of the rolls due to poorly lubricated necks.
- 3—Improper heating of the breakdown sheets in the sheet furnace wherein the center of the pack is colder than the outside.

All of these defects cause an uneven flowing or pulling of the pack of steel through the rolls leaving high "ridges" not elongated as much as the sections between them. These ridges curve toward either the front or tail end of the pack depending upon operating conditions, such as the thickness of the pack and the rate of metal flow. Pinchers are sometimes called "spreaders" or "squeezers" which are but the beginning of pinchers.

In Fig. 9 the ridges run toward the end and close to one side of the sheet the top edge of the photograph being the side. The overall length of the pincher is about 20 in. with the tip ends of each ridge being about 2 in. apart. In Fig. 10 we have a similar formed pincher but in this case the right side of the photograph is the tail end of the pack (note the dark border of annealing oxide about 1 in. wide). In this case the ridges spread out symmetrically as they run back to

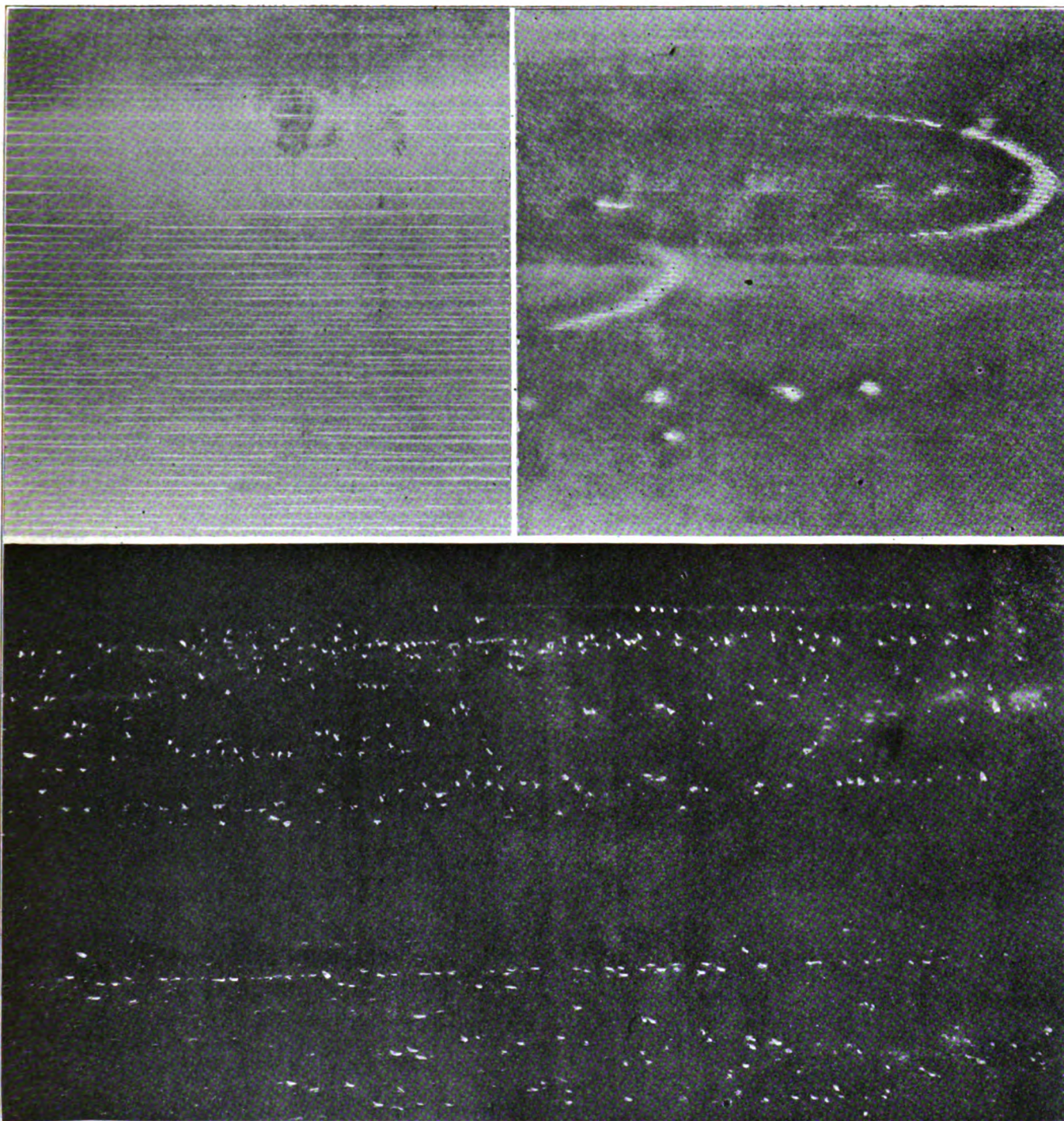


FIG. 11 (upper)—Hot mill polishing scratches, fine lines running parallel to edge of sheet (top). (Retouched)

FIG. 12 (upper)—Hot mill grease. Note annealing border (top) with grease spots elongated.

FIG. 13 (lower)—Normalizing pits. White spots are pits as much as $\frac{1}{8}$ -in. deep. Top edge is parallel to final rolling and normalizing.

ward the middle and center of the sheet. The "ribs" to the left are about 2 in. long. Pinchers can be overcome by the proper preheating of the sheets, good lubrication of the necks and running hollow packs on full rolls if the pack has been preheated properly.

Polishing Scratches

From time to time as the occasion demands the hot mill rolls are polished in order to eliminate adhering dirt which marks and pits the sheets. It quite often happens that the polishing has been so persistent and forced on a certain portion of the rolls that ridges

are left which in turn indent or scratch the sheets. In the majority of cases these so called "polishing scratches" are obliterated in the annealing and cold rolling of the sheet but it often happens that the sheet may have no cold rolling or the scratches from the black sheets are so deep that they cannot be removed in the anneal.

Fig. 11 depicts polishing scratches in a final sheet. The top edge of the picture shows the annealing border running from 1 in. to 2 in. in width along the side of the sheet. The fine polishing scratches are discernable running parallel to the direction of rolling. Sheets

of this nature are objectionable as they quite often score the stamping dies. The defect is remedied by a careful polishing with equal pressure of the polishing block across the entire width of the hot rolls.

Hot Mill Grease

While sufficient lubrication for hot mill roll necks is necessary there is damage from the application of too much, as well as too little, grease. In this respect the presence of grease splashed onto the sheets from over-lubricated necks causes the presence of such defects as illustrated in Fig. 12. In this particular example the grease struck the edge of the sheet and elongated itself with the sheet, thus forming a parabola. The grease spot has elongated itself with the ends of this parabola thus formed being about $1\frac{1}{2}$ in. apart. Note the oxide border along the top of photograph. About an inch in from the inner edge of this oxide (4 in. from the side of sheet) note the smaller blotches of grease about one-eighth of an inch in diameter. In proportion to the increase of the larger spots of grease one can readily imagine what a small amount of grease could have caused their subsequent growth to one-eighth of an inch.

Normalizing Pits

We now come to the presence of normalizing pits so recently discussed. These are caused, we assume, by the accumulation of patches of oxide adhering to the wheels over which the sheets pass and in so doing these oxide patches indent the hot sheet causing a depression or pit. This pit is very objectionable for however small it opens up when the sheet is stamped causing a larger pit to form which cannot be eliminated. The latest method devised to overcome this defect is the use of a dummy sheet on which the sheet to be normalized rests. Thus it is the dummy sheet that becomes pitted, but this mode of operation is costly and slows up production.

Fig. 13 clearly illustrates these pits formed after the sheet has been pickled. These depressions range in size from the head of a pin to $\frac{1}{8}$ in. x $\frac{1}{16}$ in. In all cases they run parallel to the direction the sheet is being fed through the normalizer. (Top edge parallel to direction of rolling and normalizing.) In this particular case the sheet is badly pitted from a great many wheels. In many cases only a few wheels might be badly oxidized and thus the sheet would show pits only occasionally.

Pickling Patches and Wood Pits

In the pickling of sheets we find blisters, previously explained, and "patches" or "black spots" as illustrated in Fig. 14 as well as "wood pits" shown in Fig. 15. In the case of Fig. 14 these "black patches" or "pickling patches" are caused by two sheets adhering to each other. Quite often two adjacent sheets in the pickling rack will adhere in several places with this union, aided by the action of the heat of the acid. The size of these patches will vary, the one in Fig. 14 being about 2 in. x 3 in. in size. If the sheets are exceptionally flat perhaps some sheets will only slightly adhere with the resulting black patch area being about 1 in. square. If the sheet is badly bowed black patches as big as 5 in. square are not uncommon. The practical remedy for this defect is to have sufficient agitation of the bath so that the sheets will not stick together. Sheets showing this defect are repickled.

The use of wooden tubs promotes the presence of wood slivers torn off by the violent agitation of the acid. Quite often these pieces of wood get between the sheets, are pressed into the surface of sheets and cause a deep pit as shown in Fig. 15. This particular illustration shows an impression about one-sixteenth of an inch deep, three-quarters of an inch long and one-eighth inch wide left by a sliver of wood which was caught between two sheets while they were being pickled.

Annealing Oxide and Open Surface

The annealing of sheets produces objectionable oxide borders and aggravates open surface which indirectly causes a sticking together of the pile of sheets. Several fine examples of oxide border have been shown such as Figs. 2, 11, and 12. The majority of orders will allow this oxide border as it is part of the "flash" or trim of the stamping. However, certain parts which are electroplated with chrome or nickel require a clean sheet which means the sheet must be deoxidized to eliminate this border.

"Open surface" is best shown in Fig. 16 which, upon first scrutiny, appears to be a hazy white surface. This in reality is made up of thousands of small

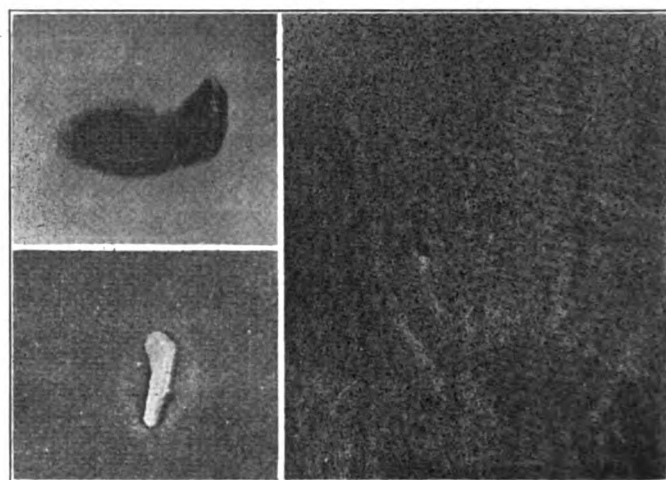


FIG. 14 (upper left)—Black or pickling patches.

FIG. 15 (lower left)—Wood pits from wooden pickling tanks.

FIG. 16 (right)—Open surface covered with small pits in countless numbers.

white pits ranging in size from the point to the head of a common pin. Rough hot mill rolls start a surface of this nature and it is most prevalent on sheets which receive a minimum amount of cold rolling. Cold rolling tends to close these pits and smooth up the surface of the sheet. Open surface, while preferred by some stamping concerns, presents a sandy rough surface objectionable for body stampings. This open surface sheet often causes a sticking of sheets when annealed as these countless pits and hummocks of one sheet interlock with the pit and hummocks of the adjacent sheet which, under high temperature and pressure cause considerable mechanical adherence. This can be overcome only by cold rolling to remove the majority of these pits and thus smooth the sheet together with an annealing range at a lower temperature.

(To be continued)

A Study of Sulphur in the Basic Process

Manganese Is Studied as a Desulphurizing Agent in the Blast Furnace Process—Effect of High Manganese Pig in the Basic Open-Hearth

By HAROLD L. GEIGER*

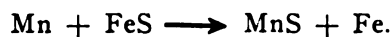
PART II

FROM the results of Prof. McCoffery's investigation the solubility of manganese sulphide in blast furnace slags is twice that of calcium sulphide. That is, for a given slag at a given temperature there will be twice as much manganese sulphide taken up as calcium sulphide. This refers back to Johnson's fifth point in sulphur removal, i.e., "Increase the manganese content of the metal."

The desulphurizing power of manganese is recognized by all steel men, today. Its beneficial effect has long been known and that it was highly valued was evidenced by the strenuous litigation which took place over the validity of the patent of Heath¹ who was the first to apply it to the manufacture of crucible steel for converting inferior grades of blister steel into grades of excellent quality. Bessemer recognized its effects in some of his first blown metal trials, while Hackney² states that it makes steels forgeable, and the amount of manganese required is from three to five times the amount of sulphur to prevent "red shortness." Up to this time its action was not fully understood as a deoxidizer and a desulphurizer. In 1896 Andrews described certain inclusions in steel as "generally of the ovoid dove-colored type" when manganese was present in excess. Arnold and G. B. Waterhouse³ showed for the first time that these dove colored inclusions were manganese sulphide.

Reaction Between Manganese and Sulphur

Theoretically one part sulphur in steel requires 1.73 parts of manganese to form MnS, but from a practical operating standpoint, four times as much manganese is required. The desulphurizing action of manganese takes place according to the following reaction:



The nature of this reaction was shown by Hilguistock⁴ who performed experiments to find out whether the reaction between Mn and FeS was a balanced one or went to an end point. He poured 400 grammes of molten 80 per cent ferro-manganese into 440 grammes of molten FeS, and the resulting metal button weighed 406 grammes and contained 9.4 per cent Mn and 90 per cent Fe and just a trace of sulphur. McCance⁵ duplicated these experiments with the following results:

Analysis of Slag.

	Hilguistock	McCance
MnS	85.75	84.1
MnO	9.11	6.1
FeO	4.74	3.2
SiO ₂	.30	5.5
	100.30	98.9

*East Chicago, Ind.

the large per cent of MnS in these slags proves rather conclusively that the reaction goes to an end point.

In order to get a high manganese pig iron, (2.0 per cent Mn) manganiferous iron ores containing 6 to 8 per cent Mn have to be added to the burden of the furnace in correct proportions to obtain an iron with 2.00 per cent manganese. A certain per cent will be lost to the slag. It is impossible to state with mathematical correctness the per cent of desulphurization accomplished by manganese in blast furnaces making 2 per cent manganese pig irons. However, it might be mentioned here that ferro-manganese, spiegeleisen and pig irons containing from 6 to 10 per cent manganese contain only traces of sulphur. The reason for the low sulphur Swedish Bessemer and open-hearth steels is due no doubt to the manganese content of their pig irons which run 3.00-3.50 per cent in that element.

Some idea may be gathered from the following casts taken from four of six furnaces operating on lake ore, high manganese practice⁶ to show the relative desulphurizing action of high manganese pig iron.

Furnace	Cast	Mn.	Phos.	Sul.	Sil.
A	1	2.34	.217	.018	1.35
C	3	1.90	.209	.023	1.25
D	{ 1	1.62	.202	.027	1.25
	{ 6	1.58	.207	.036	.80
F	{ 5	1.26	.207	.056	.60
	{ 1	1.88	.222	.030	.97

These figures present the relative desulphurizing action of manganese and also the relation of silicon to sulphur. Cast 1 from furnace A which ran 2.34 manganese showed a low sulphur content of .018. This condition was aided by the furnace running on the hot side for basic pig iron as indicated by the 1.35 silicon. Cast 1 and 6 from furnace D are of interest because the manganese is practically the same, i.e., 1.60 per cent, but the silicon is on the high side in cast 1 and the sulphur is relatively low, while in the instance of cast 6 taken a few days later the silicon dropped to the lower limit of .80 and the sulphur showed an increase up to .036. This shows the effects of the silicon to a marked extent. Cast 5 from furnace F is very instructive and shows the combined effects of both Mn and silicon. The manganese is low, (1.26 per cent) for manganese pig practice and the silicon is very low (.60 per cent) resulting in a sulphur content of .056. This furnace was operating on the cold side with the following conditions to produce these results.

(a) Large per cent of unreduced FeO in slag inhibiting desulphurization.

(b) Large loss of manganese in the slag as MnO, only a part being reduced to the metal.

(c) Cold furnace decreased the solubility of CaS and MnS in the slag.

(d) Larger per cent of silica in slag required relatively larger amounts of lime to neutralize it, leaving less than the usual amount for desulphurizing action.

Manganese Makes Free Running Slag

Another benefit of high manganese practice is its effect upon the free running temperature of the slag. Manganese in general makes a more fluid slag and one with a lower free running temperature. This is brought out in Bessemer practice; where high manganese pig irons are used the resulting slags are very thin and watery, both in American acid practice and European basic practice.

The action of manganese as a desulphurizer is somewhat different than lime, in that, manganese desulphurizes in the metal, while lime does its work in the slag or at the slag metal interface. The sulphur is present in the metal as FeS while the manganese may be present as a carbide or in solid solution with the iron. The reaction between the FeS and the manganese goes to an end point as shown above and a non-metallic inclusion MnS is formed which rises to the slag, due to its specific gravity (4.00) and becomes absorbed. This reaction takes place not only in the metal bath in the crucible of the bath furnace, but also in the pig iron ladle.

Herty⁷ has carried on some experiments to show this action in the ladle. He concludes that when the product of the per cent of manganese times the per cent of sulphur is under .070 at the blast furnace, none or very little desulphurizing will take place in the ladle. He presents in graphical form an excellent record of his tests to show this. Some of the values taken from his chart bring this out:

Mn.	Sul. at fce.	Sul. after in ladle	(% sul.) x (% mn.) at fce.	(% sul.) x (% mn.) in ladle
2.16	.062	.030	.134	.065
2.00	.053	.032	.106	.064
1.82	.032	.029	.058	.056
1.84	.046	.040	.084	.073
1.67	.085	.037	.142	.062
1.60	.072	.040	.115	.064
1.40	.098	.050	.137	.070
1.22	.082	.057	.100	.069

From these figures it is evident that the higher manganese is the more efficient sulphur remover, and that the final sulphur values increase almost directly in proportion with the decrease in manganese content. In the fourth column, the product (per cent S) × (per cent Mn) shows figures well above .070 except for the third case where the product was .056 and the sulphur showed only a drop of 3 points from .032 to .029. The last column, product of (per cent MnO) × (per cent final Sul) averages .067 and agrees for all practical purposes with Herty's value of .070. If all of the values had been taken from Herty's graph the average products would be nearer to .070. This value may be used when there is no blast furnace slag present on the metal.

Similar experiments⁸ were performed at the Bethlehem Steel Company on No. 3 open hearth shop for a month to study the effects of high manganese iron on the blast furnace and open-hearth operations. No. 3 blast furnace was run on high manganese iron with lean slags and of course high sulphur metal. Samples

were taken at the furnace and 80 minutes later at the mixers on 136 ladles in the following groups:

First group iron with 1.00 to 1.50 manganese
Second group iron with 1.50 to 2.00 manganese
Third group iron with 2.00 to 2.00 and above

The results of the above are given below:

Group	No. of tests	% sul. at b. f.	% av. mn.	% sul. at mixer
1	21	.0867	1.39	.040
2	89	.070	1.72	.035
3	26	.073	2.13	.031

Effect of Silicon

Wheaton found that the per cent of silicon to give the best sulphur removal in the ladle in the high manganese pig practice, was below 1.00 per cent and explains the reason for this as follows:

When MnS is formed it rises to the top of the ladle and in the presence of low silica (SiO₂) is broken up to Mn and SO₂ and part of the manganese is thrown back to the metal, the SO₂ passes off as a gas, and the balance of the manganese forms a slag of MnO.SiO₂ (manganese silicate). When silica is present in excess, FeO.SiO₂ (iron silicate) is formed. This in the presence of MnS, FeS, and Mn SiO₄ will throw sulphur back into the metal as a compound and an incomplete reduction of sulphur takes place.

In the case of high manganese iron elimination of sulphur takes place in the hot metal mixer if the SiO₂ is kept low in the slag. The greatest removal is accomplished when the ratio

$$\frac{\text{SiO}_2}{\text{MnO}} = 0.80 \text{ in mixer slag.}$$

The yield in No. 3 plant was 90 per cent. Their residual manganese averaged 0.34 per cent and no difficulty was had with sulphurs.

This work of Wheaton confirms the statement of Kinney⁹ who found that .04 per cent sulphur in steel can be regularly and economically produced from such iron (2 per cent Mn) even though its sulphur content may be .07 per cent. His observation of the effects of high manganese pig practice on the blast furnace and open hearth agrees with the observation of Smith. Smith¹⁰ gives the following advantages of this practice on blast furnace operations:

- 1—The higher manganese tends to increase the rate of driving, which is due to a more fluid iron.
 - 2—Troubles due to high bottom are reduced.
 - 3—Less runner and ladle scrap is produced.
 - 4—As a general rule, higher blast temperature can be used if the manganese of the pig is not carried too high. Lower coke consumption is obtained than in the production of lower manganese pig iron.
 - 5—Less flue dust produced.
- The advantages in open hearth practice are:
- 1—Elimination of sulphur.
 - 2—Purifying action in the bath which tends to produce a better quality steel with fewer inclusions.
 - 3—Saving of ferro-manganese.
 - 4—Decrease lime charge and a saving of fluorspar.
 - 5—Increase tonnage.

The disadvantage appears to be furnace bottom and slag line scorification. This could be reduced to a minimum by proper slag manipulation.

A study made by Smith of 1000 heats of open-hearth rimmed steel to meet deep drawing requirements, showed that the best and cleanest steel was produced by charges containing 1.50 to 2.00 per cent manganese pig.

This leads up to a consideration of residual manganese in the open hearth process and its relation to sulphur removal. The residual manganese in the bath seems to bear a general relation to the manganese in the pig iron. Where open-hearth steels are made using a 45-50 per cent hot metal charge of 1.00 per cent manganese iron or under, the residual manganese averages between .08-.16 per cent while, a 1.50-2.00 per cent manganese pig will give a .23-.25 per cent residual manganese. What, in the author's opinion should determine the amount of residual manganese, to a large extent, in the bath is the composition of the slag, near tapping time.

That the residual manganese varies in different shop practices, is indicated by the fact that Wheaton obtained a residual manganese of .34 per cent as compared to Smith's 0.23 per cent, while Kinney gives eight types of open hearth heats and reports residual manganese from a .12 to 0.40. The latter value was attained under most favorable conditions, i.e., high manganese iron, low silica content of charge and no run-off slag. Pazzetti¹¹ in discussion of the works of Kinney reports a month's practice using 1.65 manganese in the iron and shows a residual of 0.22 when using no run-off slag while in a plant using a run-off slag the record of five carefully observed heats showed average residual manganese to be .09 per cent when the average manganese in the pig iron was 1.69 per cent.

The advantages of high manganese iron in the bath are to aid in the more desulphurization process and to insure a more thorough deoxidation in the working of the heat and also to save in ferro-alloys. The saving in ferro-alloys amount from 15 to 25 per cent. This means a smaller number of inclusions such as MnS and Mn SiO₃ formed and thereby a cleaner steel. The added fluidity that the MnO imparts to the slag effects a saving of 12 per cent fluorspar on heats using 1.50-2.00 per cent manganese iron over heats using 1.00 per cent manganese iron.

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The Use of Metallurgical Limestone

(Continued from page 1312)

assimilated slowly in the melt. No definite data have ever been assembled on the rate of assimilation of various limestones in the open-hearth slag; nor, so far as I am aware, has a discussion of this problem ever appeared in print.

Acknowledgments

The writer desires to acknowledge many helpful suggestions from S. P. Kinney, T. L. Joseph, and C. H. Herty, Jr., metallurgists of the Bureau of Mines.

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STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

(Required by the Act of Congress of August 24, 1912)

Name of Publication: Blast Furnace and Steel Plant, published monthly at Pittsburgh, Pa. (Report of October 1, 1928.)

Publisher—Steel Publications Inc., 108 Smithfield St., Pittsburgh, Pa.

Editor—Donald N. Watkins, 108 Smithfield St., Pittsburgh, Pa.

Managing Editor—Charles Longenecker, 108 Smithfield St., Pittsburgh, Pa.

Business Manager—Donald N. Watkins, 108 Smithfield St., Pittsburgh, Pa.

Names and addresses of Stockholders holding 1 per cent or more of total amount of stock:

Steel Publications Inc., 108 Smithfield St., Pittsburgh, Pa.

Donald N. Watkins, 108 Smithfield St., Pittsburgh, Pa.

M. M. Zeder, 108 Smithfield St., Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

DONALD N. WATKINS, Business Manager.

Sworn to and subscribed before me this 26th day of September, 1928.

CHAS. A. SEIBERT, Notary Public.

(My commission expires March 8, 1931.)

Design and Operation of Strip Mills*

Further Development of Equipment Is Illustrated in Four Mills
Indicating the Trend Toward Greater Production and
Increased Adaptability in Size Ranges

Translated by R. W. DIEMEL†

PART I (Continued)

A MORGAN mill of the straight continuous type is represented in Fig. 8. The billets 9 meters long, 50 or 60 square (27 ft. x 2-2.36 in.) are delivered by trucks to the producer-gas heated furnace. The handling into and out of the furnace is done mechanically, the billet coming from the furnace being pushed straight into the first stand. As shown, there are two separately driven continuous mills in straight line. Between the two is a compensating stand and a flying shear. Different from the spur wheel gear of the rougher, the finishing strand, on account of the high velocity, is belt driven, of which peculiarity special mention shall be made here. As shown in Fig. 8, three belts each 1 meter wide (39.4 in.) are running one atop of the other. Transfers are placed between the stands of the finishing mill. The band issues from the finishing mill at a velocity of about 12 meters per second (39½ ft.) and is deposited on a conveyor belt by a loop-thrower and then coiled by two reels. The rolls are pierced and have no wobblers, they are driven by square spindles extending through the hollow part. This allows a lateral movement of the housing when adjusting the passes in straight line.

No doubt the straight continuous mills have great advantages compared with the ordinary type. The stock is handled much faster, and remains a shorter time exposed to the oxidizing and cooling influence of the atmosphere, so that the stock, apart from lower power consumption of the drive, shows greater uniformity in width and gauge at the beginning and end, also a better surface and hardness, scraping being unnecessary.

On this mill remarkable band-lengths and coil-weights can be produced. By extensive use of mechanical equipment a great production is possible, for instance about 125 tons per 10 hour shift, rolling strip 55 x 1.5 mm. (2.165 x .059 in.). The capacity per month averages about 70 to 80 tons per shift with strip from 25 to 70 mm. wide and .9 to 3 mm. gage (.984 to 2.755 in. x .0354 to .118 in.). It must be mentioned that a mill of this description can operate economically only when turning out large quantities.

Mills for Wider Strip

In the foregoing a description has been given of strip mills for the production of bands under 80 mm. (3.149 in.), in grooved rolls. The rolling of wider strip developed along similar lines. One of the oldest mills of this type is shown in Fig. 9. Same as all mills of that time it is of the open type. Of particular interest is the use of double duo stands for the rolling of wide strip. This permits changing passes from bottom to top without impairing the accuracy of the sec-

tion. It also shortens the rolling time. This mill still uses sheet bars as raw material.

Meanwhile experience had been gathered with the operation of continuous mills for narrow strip. This has been utilized in the remodeling of a mill in 1910, as demonstrated in Fig. 10.

However, the application of the continuous system is limited to the roughing mill. The three-high stand (which had been used so far) has been replaced by four two-high stands in straight line, with increasing speed ratio, the third stand being an edger. The side strand with two double duos has a drive of its own with Kramer control.

This mill is conspicuous by the absence of grooved rolls. Only the edgers have deep-cut passes which together with the central starting arrangement of the top roll enables quick changes to any width within the range of sections.

Whereas with the equipment used up to this time the capacity of a mill was limited by the capacity of the rougher, conditions are reversed after introduction of the continuous roughing mill. It therefore became necessary to increase the capacity of the finishing mill. This was attained by installation of mechanical transfers in connection with the open double duo strand. After leaving the roughing mill the hot stock runs over a chute into a conveyor trough. A roller run delivers it into the first double duo of the finishing strand. The mechanical transfer from bottom to top is made by a Quast-Lomberg repeater. The stock is then transferred to the lower rolls of the second double duo. Only in special cases, when both ends require scraping, this will be done after the sixth pass. In this case the band is run out onto a chute, and conveyed to the semi-finishing stand by means of a truck. The transfer from semi-finishing stand to the finishing stand is still hand-operated, but also in this instance manual labor will soon be eliminated and replaced by reverse rollers.

To meet the ever increasing requirements regarding surface purity of the strip special attention was directed to the scraper equipment of this mill. In the older mills the scraping beams were hand operated, and later by the foot of the roll-man. Only many years later the scrapers were operated by steam, or compressed air. In case of the mill shown in Fig. 10 the band is scraped before the sixth, seventh and eighth pass, in order to destroy any scale formation between the last passes.

The highest production amounted to approximately 120 tons per shift, in strip 130 x 2 mm. (5.117 x .0787 in.). The average production is about 70 tons per shift. The finished band is 70 to 160 mm. wide (2.755 to 6.299 in.) and 1 to 6 mm. thick (.0394 to .236 in.).

Design for More Varied and Greater Production

The development of the mills described above is characterized by ever increasing use of machinery.

*Strip mills of the firm of Thyssen (Ruhr) and Dinslaken by Dipl. Engineer F. Winterhoff, Dinslaken. (Report No. 58 by the Rolling Mill Committee of the Verein Deutscher Eisenhüttenleute.)

†From Stahl und Eisen.

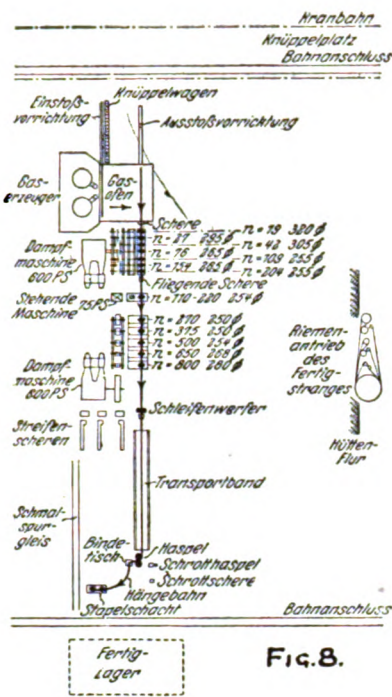


FIG. 8.

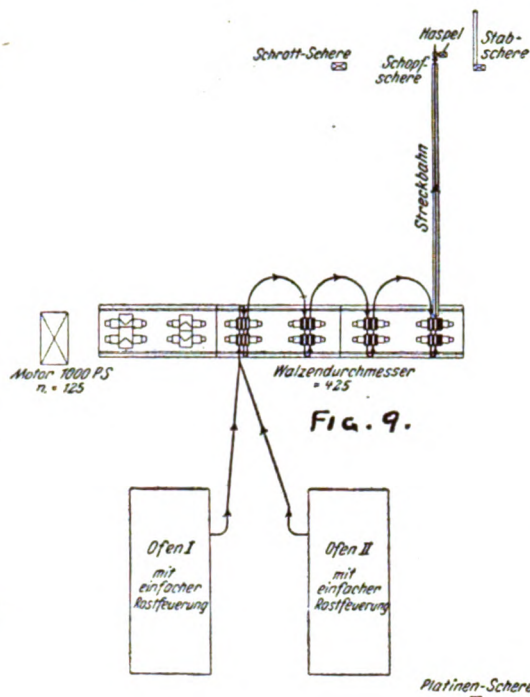


FIG. 9.

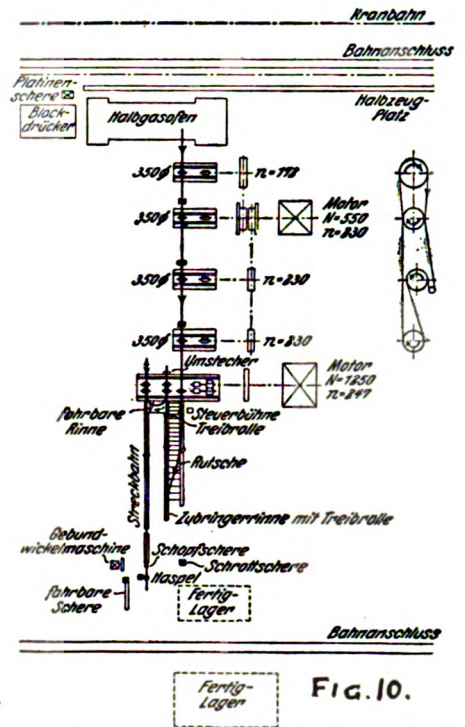


FIG. 10.

FIG. 8—Straight continuous strip mill. Kranbahn—crane track; knueppelplatz—billet storage; bahnanchluss—siding; knueppelwagen—billet truck; einstossvorrichtung—pusher; ausstossvorrichtung—pusher; gas-erzeuger—gas producer; gas ofen—gas furnace; scheere—shears; dampfmaschine—steam engine; fliegende scheere—flying shears; stehende maschine—vertical engine; streifenscheeren—strip shear; schleifenwerfer—loop thrower; transportband—belt conveyor; schmalspurgleis—narrow gauge track; bindetisch—bundling table; haspel—reel; schrotthaspel—cobble reel; schrottscheere—cropper; haengebahn—suspended trolley; stapelschacht—storage pit; fertiglager—storage yard for finished product; riemenantrieb des fertigstranges—belt-drive of the finishing strand; huetttenflur—mill floor; bahnanchluss—siding.

FIG. 9—425 mm (16.732 in.) double duo strip mill. Schrottscheere—cropper; schopfscheere—shear for ends; haspel—reel; stab-scheere—bar cropper; streckbahn—run-out; walzendurchmesser—diameter of rolls; ofen I mit einfacher rostfeuerung—furnace L ordinary stoker fired; ofen II mit einfacher rostfeuerung—furnace L ordinary stoker fired; platinen scheere—pair cropper.

FIG. 10—Semi-continuous strip mill. Kranbahn—crane track; bahnanchluss—siding; platinenscheere—pair cropper; block-druecker—ingot pusher; halbgasofen—semi-gas furnace; halbzeugplatz—raw material storage; umstecher—repeater; fahrbare rinne—traveling trough; steuerbuehne—pulpit; treibrolle—feed roller; rutsche—chute; streckbahn—run-out; zubringerrinne mit treibrolle—conveyor trough with feed roller; gebundwickelmaschine—bridling apparatus; fahrbare scheere—traveling shear; schopfscheere—end cropper; schrottscheere—cropper; haspel—reel; fertiglager—finished goods storage; bahnanchluss—siding.

With wages constantly rising, and the partial introduction of the eight hour day production costs must be reduced to a minimum by saving of labor. At the same time Germany, besides increased production at lowest costs and a simultaneous saving of labor, has to reckon with a very wide range of sizes, requiring greatest flexibility of the mill. For this reason the latest strip mill was again designed as a semi-continuous mill, instead of straight continuous. Price and space were also of first importance. To this must be added that in recent plants, owing to the introduction of mechanical transfers, the open arrangement of the finishing strand is in no way inferior to the straight continuous mill.

The general layout of this mill is represented in Fig. 11. The tandem roughing train has been enlarged to eight stands, permitting a greater cross section of the raw material and thus ensuring better surface conditions of the strip. The continuous stands have been spaced so far apart that the stock can run out freely between the housings. It must be considered that the new plant had to be installed in an existing building, with the old mill still in operation. Between the shutting down of the old mill and the placing into operation of the new plant was an interval of only two months.

The mill rolls slabs of widely varying widths and lengths. The slabs are heated in a semi-gas furnace of about 15 tons capacity. Coal is carried to a hopper

above the furnace doors. The electrically operated ingot pusher and the furnace are of compact construction owing to lack of space.

The slabs are charged in two rows, and, after travelling through the furnace, drop into a pit in the welding hearth. They are discharged from there by a roller device, placed on edge and pushed into a vertical pair of pinch rolls, which delivers them to the right edging pass. The time from placing the slabs into the furnace to delivery into the mill averages four hours. The continuous rougher comprises eight two-high stands, the speed ratio increasing from housing to housing in order to compensate for the increasing length of the band. The main strand has two double duo stands of equal velocity. The first continuous stand is an edger, capable of reducing the slabs down to 70 mm. (2.755 in.). Thus stocks of raw material may be kept small with the added advantage of thoroughly breaking the scale.

Back of the edger the slab, by suitable design of the rollers, is turned 90 deg. and in this position delivered into the second stand. It then progresses through five two-high stands, roller runs being provided which carry the stock from one housing to the other. The seventh pass is the finishing edger, which planishes the stock along the edges and reduces it to the requisite width. After leaving the semi-finishing mill it runs onto a chute, from where it is taken to a conveyor trough by means of a mechanical kick-

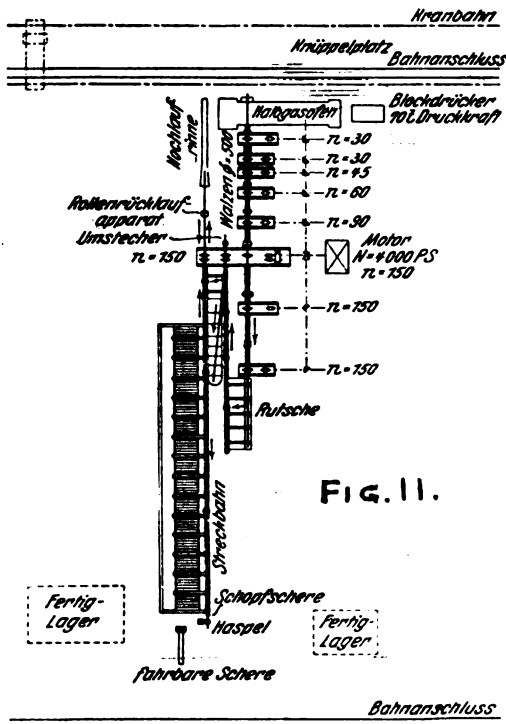


FIG. 11.

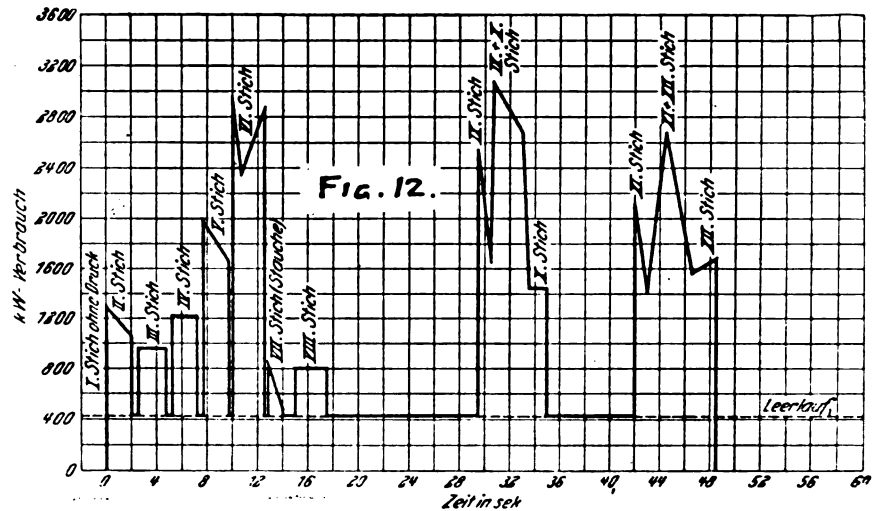


FIG. 11—Semi-continuous strip mill. Kranbahn—crane track; knüppelplatz—billet yard; bahnanchluss—siding; hochlaufrinne—elevated run-out; halbgasofen—semi-gas furnace; blockdrücker—billet pusher; druckkraft—pressure capacity walzen—rolls; rollen rücklauf apparat—roller reversing device; umstecher—repeater; rutsche—chute; streckbahn—run-out; schopfscheere—end cropper; haspel—reel; fahrbare scheere—traveling shear; fertiglager—finished products yard; bahnanchluss—siding.

FIG. 12—Power consumption during the rolling of a slab 280 x 75 x 1000 mm into strip 280 x 2.75 mm. K.w. verbrauch—kilowatts consumed; stich ohne druck—pass without pressure; stich staucher—(pass edger); leerlauf—running idle.

off. A flying roller is placed in operation and shoots the strip through two pinchroller stands into the first double duo of the main strand. The repeater back of the housing reverses the band automatically in the upward direction. According to the intended quality of the finished product the strip is scraped during this operation and subjected to an air blast of about 8 atm. In order to make sure that both ends of the strip receive at least one polishing pass the band, after leaving this stand, is run onto a long chute, in order to reverse the direction of the rolling. A chain drag delivers it under a flying roller, which introduces the band into the semi-polishing rolls. A reverse roller run then delivers it to the finishing rolls. Here again, before both passes, the strip is treated in the manner already described, by scraping, blowing and rinsing in plenty of water, in order to produce a planished blue surface. Two operating platforms are provided for the control of the auxiliary and scraping equipment.

Proper grouping and easy manipulation of the controls on the operating platform is very important for the smooth working of the mill, also a carefully selected crew of operators.

The run-out is about 55 meters long (180 ft.) and runs parallel with a mechanical cooling bed of same length. The strip, at the end of the run-out, is reeled into coils weighing about 300 kilos (660 lbs.) which are ejected from the reel by air pressure. A cropping shear cuts the two ends before and after the coiling. The strip to be furnished in straight lengths is kicked off the run-out and stocked in hot piles, which are moved slowly over the cooling bed by drags. The gradually cooling stock is cut to requisite lengths by a traveling shear at the head of the cooling bed and banded as specified.

In consideration of the broad range of specifications great attention has been given to fast change of sections. Both edging stands are therefore provided with central starting device.

Of particular interest is the drive of this mill. It is driven by a 4,000 hp. a.c. motor. The main line shaft transmits the power through a pinion housing to the double duo strand. The continuous stands receive their power through pinion housings and bevel wheel gear from a double line of shafts, which are driven from the main shaft by means of bevel wheels. All bearings and gears are lubricated by a central oiling system. Special devices of control insure the equipment from running dry.

The speed and power ratios are shown in Fig. 12. The curve refers to the rolling of a slab 280 x 75 x 1000 mm. (11.023 x 2.952 x 39.370 in.) into bands of 280 x 2.75 mm. (11.023 x .108 in.). The total rolling time amounts to only 48.5 sec. This short time protects the stock from excessive cooling, so that with good heat and low power consumption a thinnest possible band with clean surface can be produced. The diagram does not represent a clear picture of peak performances, because at the time of investigation the mill was so adjusted for the simultaneous rolling of several slabs that the peaks did not coincide.

All auxiliary equipment is driven by electricity and placed under floor. The general layout and design of the mill have been entirely satisfactory and the production obtained was fully up to expectation.

By use of machinery wherever possible labor saving has been brought to a highest possible point. The mill proper requires for the rolling of normal sections not more than four men, beside the foreman.

The mill was built for an average production of about 120 tons per shift, for strip 150 to 400 mm. wide (5.905 to 15.748 in.). So far peak productions of about 130 tons per shift have been attained, rolling strip 200 x 3 mm. (7.874 x .1181).

The last five stands roll at a velocity of about 5 meters/sec. (985 ft./min.). It turned out that the mill can produce considerably more than originally expected, if another furnace is added. Room conditions permitting the installation of a second furnace the scheme is now under consideration.

Safety from the Viewpoint of Supervision*

**Straight from the Front Line in the Fight for Prevention of
Accidents Comes This Very Practical Talk—
Safety Assured by Co-operation**

By DOMINIC SAMUELS†

WITH the difficulty I experience in expressing my thoughts in English I hesitated for some time before accepting this invitation. I also feel that the men speaking before this convention are specialists on safety, and as I can only offer a review of safety as it applies to my own department it may be that many of my remarks are repetitions of safety ideas brought before this council on previous occasions.

Right at this time I wish to say that when this safety drive first started in earnest, our management, through our superintendent, instructed myself and other foremen what was expected of us, advising us also that we would be held accountable for the safety of our men. He also advised us that his office would give every possible assistance and backing, and explained that the safety first idea was to be given preference over production.

I am foreman in the tube galvanizing department, Campbell plant, of the Youngstown Sheet & Tube Company. To those of you who are not familiar with the procedure in a galvanizing department I will mention that we have, as major hazards, caustic soda, sal-amoniac, muriatic and sulphuric acid, and also molten spelter to contend with, and until this safety first drive was in force the appearance of the accident investigator was a daily or weekly occurrence in my department.

From my own experience, bringing this thought to sub-foremen and men was no easy matter; their idea at first being that it was only a fad and that it would soon die out. Needless for me to say that after attending meetings conducted by our superintendent, my ideas were different. As a foreman it was my duty to carry out the instructions of my superior, and I went into the matter heart and soul to eliminate as far as possible the hazards in my department. It was not long until I realized that our most serious hazard was the attitude of my men toward safety, and after making a few mechanical safeguards I set out to drive home to each man a safety thought.

After a short while I specified that on a certain day and hour each week I would conduct a safety meeting and advised the men that they would have to attend. What transpired at these meetings was recorded and a copy of the minutes was sent to the superintendent and the safety director. At these meetings I explained to the men the hazards of their work and how they could best guard themselves against danger. I explained the actions of the different acids used in connection with galvanizing, and how this material coming in contact with their bodies would cause serious burns, and how easily eye sight could be destroyed. With the exception of very few, the men in my department are compelled to wear goggles. In order to keep safety on the minds of my men I

also placed signs at each pot bearing helpful safety suggestions.

As many first aid ideas as possible have been demonstrated at these meetings and on several occasions application of these ideas have been beneficial. Just recently the clothing of a man in our department caught on fire and, as seems to be the natural thing for many men to do, he started running; but one of his fellow workmen remembered the teachings as conducted in my office and immediately grabbed him and threw him to the floor, smothering the flames with his own coat. These acts are also given consideration by our management and this man was given a silver medal, and his act given publicity throughout the plant.

My men have all been instructed to be on the lookout for hazards and to make a report of conditions that they think can be improved upon. It is not unusual for my men to speak to their fellow workers if they, in their mind, think that they are not following the safety ideas and practices as closely as possible; and I have had men report to me on several occasions where these men have resented having their attention called to this matter. I then make it a personal matter to caution these men, and if I could not thoroughly impress them with the importance of safety they did not remain long in my department.

I notified my men that, owing to the possibility of acids splashing, they would have to wear high top shoes and that the soles would have to be in first class condition: Inspections were made to see that these instructions were complied with, and if a man reported with shoes that were not in good condition he was immediately sent home. I do not hire my men direct. My calls for men are placed with what we call the "labor department," and it was only a short while until the foreman in charge knew it was useless to send a man to my department unless his shoes were in good condition.

Safety discussions at our meetings were not confined only to our own department but covered entering and leaving the plant, and also urged that the safety idea be carried back to the home. They were urged to explain the first aid ideas and artificial respiration to other members of their families. Men were cautioned that if they were placed in some different work that they were not familiar with they were not to proceed until they had been thoroughly instructed concerning the hazards of the job. Where men have been instructed concerning these hazards and violate instructions, even though no accident occurs, they are disciplined. I sometimes suspend or dismiss them depending on the attitude they take towards safety, or sometimes demote them.

It is difficult to explain here the proceedings of these meetings and the various items that we discuss, but everything that concerns safety as is applied to this department was given consideration; and, as stated

(Continued on page 1328)

*Paper before the National Safety Council, Metals Section

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Handling Problems in the Open-Hearth

Suggestions to the Material Handling Engineer from the Operations of the Open-Hearth Show a Broad Field for Constructive Planning

By J. RICHARDSON

MATERIALS to be handled in the operation and repair of the open-hearth are more or less a fixed classification; however, the conditions under which the work is done vary in the different plants to quite a degree. Each plant layout differs from the others, because of general plant conditions, results to be obtained, variety of product and age of the plant; so that, while it would seem that uniform systems and standardized mechanical devices should naturally be applicable to all, there is in reality a variety in the requirements for mechanization which has made the progress along that line rather slow. In a general way it may be stated that each plant requires special study in making improvements in the methods employed in moving materials.

The materials involved in the regular course of operations may be listed as follows:

Material	How received	Where used
Hot metal	Ladles	Furnace hearth
Cold pig	R. R. cars	Furnace hearth
Scrap	R. R. cars and buggies	Furnace hearth
Scale	R. R. cars	Furnace hearth
Ore	R. R. cars	Furnace hearth
Limestone	R. R. cars	Furnace hearth
Burnt lime	Box cars	Furnace hearth
Spar	Box cars	Furnace hearth
Ferro manganese	R. R. cars	Bath or ladle
Ferro silicon	R. R. cars	Bath or ladle
Alloying metal	Box cars	Bath or ladle
Sulphur	Box cars	Bath or ladle
Aluminum	Box cars	Ladle or molds
Other deoxidizers	Box cars	Ladle or molds
Raw dolomite	R. R. cars	Bottoms and banks
Burnt dolomite	Box cars	Bottoms and banks
Grain magnesite	Box cars	Furnace bottoms
Chrome ore	R. R. cars	Banks and walls
Fire brick	Box cars	Furnace construction
Magnesite brick	Box cars	Furnace construction
Chrome ore	Box cars	Furnace construction
Ladle brick	Box cars	Ladles
Sleeve and nozzles	Box cars	Ladles
Fire clay	R. R. cars	Pan house
Stone	R. R. cars	Mixers
Mechanical parts	Various	Various
Structural parts	Various	Various
Coal	Hopper cars	Producers
Oil and tar	Tank cars	Burners
Gas	Pipes	Ports
Slag	Casting pit	Slay yard out
Pit scrap	Casting pit	Stock yard
Skulls	Casting pit	Stock yard
Brick bats	Furnace, etc.	Pan house or dump
Refractory waste	Furnace, etc.	Pan house or dump
Cleanup	Various	Dump
Steel in ladle	Tap	Ingots
Steel in ingots	Mold train	To stripper

This list is given mainly to keep before us for reference the chief handling problems to be considered.

Hot metal is transported in standardized equipment, and the methods used are standard being varied to suit the magnitude of operations. The improvement of these methods and devices progresses with the

demands of production units, and involves ladle cars, ladles, motive power, trackage, cranes and runways, mixer vessels, runners and spouts and general plant layout, the objective being to serve the furnaces at the proper time metal in the proper condition, without interference with movements on the charging floor and without disturbance of the blast furnace cast schedules.

Stock Yard Problems

Cold pig is ordinarily received in railroad cars, unloaded by cranes with the magnet in the stock yard and magnet handled into the charging boxes. No particular difficulty is experienced in loading boxes to capacity and all this is standardized operation. Arrangements must be such that there is no delay in having the charge ready at the specified time.

Scrap is quite another problem. It is received in the stock yard in various ways and conditions and must be cut to charging box size. It should be reduced to such form as to facilitate the loading of boxes to maximum weight content which reacts in furnace charging efficiency. Loading with the magnet does not as a rule yield maximum box capacity and hand straightening or even hand loading often repays its cost in gain in melting. Here is a problem of considerable magnitude for the expert in materials handling in the preparation and loading of scrap. Once properly put in the boxes, subsequent handling is standardized.

In certain operations roll scale or ore is used in large quantities. Bins are usually provided into which hopper cars can be dumped from high level, or the

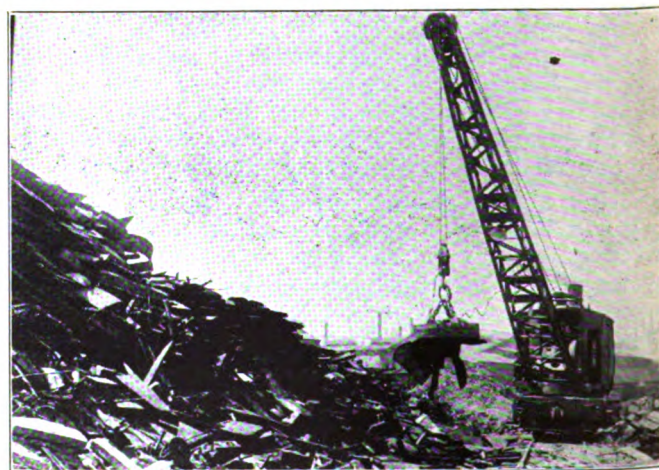


FIG. 1—Magnet handling scrap.

materials lifted by conveyors. However, the loading of the charging boxes ordinarily involves hand shoveling to quite a degree, and especially where the bins empty upon the floor the loading is done entirely by hand. Proper mechanical means for filling the boxes

saves costs and also facilitates the charging of these materials at the right time which is essential to the proper reactions of the bath.

Limestone has been mostly a hand handling proposition due largely to the size of lumps which makes the application of mechanical devices difficult. The boxes are often placed in the car for hand loading to save unloading into and reloading from piles. It is often desirable to eliminate spalls from the charge and this favors hand handling. The grab bucket while not very handy at picking up lumps is used to some extent, and special buckets are made to do this; and if the stone can be got at the side of the pile on a smooth floor it can be scooped, thus mechanical means may be applied to its handling. While under present conditions the stock yard labor needed for other operations is always available at the time the stone is to be loaded, the extent to which such labor is needed will diminish with improvements in facilities so that each item must be considered as a field for mechanization.

Burnt lime has to be protected from moisture so that it is for the most part received in box cars. For this reason the unloading is a hand job. That with proper plant layout handling lime can be thoroughly reduced to a mechanical proposition there can be no doubt, for the material itself is not as awkward to handle as the stone, being more like ore or scale in that respect. Spar, being used in smaller quantities does not present a very serious problem, with the exception that it must be kept strictly separate from the other materials.

Ferro Alloys and Refractories

Ferro manganese and ferro silicon are delivered to bins for the crusher and handled in suitable boxes. The shovel and wheelbarrow usually play too prominent a part, and a thorough system with proper conveniences solves this problem to a great degree. Alloying metals on account of their value must be stored and handled with care and under supervision of the melter. Sulphur for screw steel is a small item. Aluminum is used in considerable quantities both in bar and shot form. All these items yield to convenient containers and a proper system in general transportation. Raw dolomite is rather easily handled by grab bucket and presents no great problem other than that of proper storage convenience. Burnt dolomite like burnt lime must be protected from moisture, but otherwise presents no peculiar problems, being easier to handle than lime.

The application of magnesite and dolomite to repairs of the bottoms and banks entails much heavy labor, and several devices have been tried to properly apply, in a mechanical way, these materials. None of these devices are quite fully successful although some very definite progress has been made in the so called dolomite guns and throwers.

Chrome ore pulverized and in lumps is used in increasing quantities, and being a high cost material must be handled with some attention. The problem of handling is not very different from that of the other refractory materials except for the feature of carefulness against waste.

Fire brick, and shapes, magnesite and chrome brick, etc., are quite largely hand handled, coming in in box cars and usually stored under cover against the

time of repair or construction. Much labor cost and operating time loss is involved in any inefficiencies in getting the brick to the job, and it is to be wondered at that more studious attention has not been given to the problem of systemizing and to the devising of mechanical helps. If the mason is to have a



FIG. 2—Grab bucket handling limestone.

chance to make good time in completing the construction or repair job and not be hindered in doing a good job he must have the best of service and this usually entails much rehandling over difficult paths of transit. The bricks must be promptly available, kept dry and protected from breakage or spalling and for these reasons the application of mechanical methods has been difficult and backward. Roller conveyors, chutes, proper boxes and buggies, crane service, motive power and proper systemization play a part in making up for inconvenient layout of the plant. In designing a plant too much attention cannot be given to the provisions for caring for brick, in fact these provisions should be as carefully planned as those for handling steel making materials.

Ladle brick should not ordinarily present much of a problem as the ladle repair space should, and usually does, provide for unloading and stocking; conveniences for getting the brick from the stock into the ladles are mostly pretty rough and ready and here is offered a good field for improvement. Sleeve and nozzle bricks are usually stocked conveniently to the work so that unloading and stocking are the problems involved. The care and protection of sleeves, stoppers and nozzles and the proper handling of the finished stoppers varies greatly and these are often subject to rough handling, water and breakage all of which is as unnecessary as it is careless.

Fireclay is ultimately delivered to the pan house, but meantime is often stored at outside points and subject to wastage and contamination. Much use is made of the hand shovel although the loading and unloading of cars is done with the grab. A thorough handling system would be welcome in almost every plant. Special cements and special refractory materials come in containers that are adaptable to efficient handling, but provisions for these are seldom available so that much labor is involved and also often the containers are wasted. Mechanical means for handling such containers flexible enough to take care of barrels, sacks, boxes, etc., would serve many useful ends.

Mechanical Spares

Repair parts both mechanical and structural must be made available on immediate notice for breakdowns or routine repairs, therefore some spares must be carried in proximity to operations. Careful and thorough plant study and means for quick transportation reduces to a minimum the annoyance to operations of a stock of spare parts, in the shop. In some cases special handling provisions are very desirable for removing and replacing some definite pieces of equipment independently of production machinery. Here the small hoist is most convenient and in many places it pays to keep one hanging up.

Coal and ash handling equipment are standardized as well as are arrangements for oil, gas and tar. Fuel handling problems are well solved as a rule by the engineers when designs are made.

Pit and Slag Disposal

The disposal of slag, pit scrap, brick bats and refuse deals with a rough and awkward material.

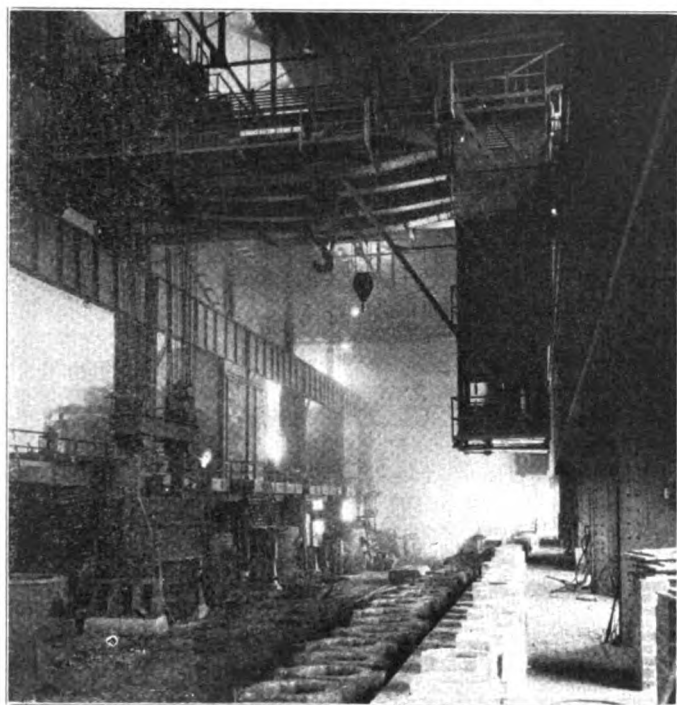


FIG. 3—View of pit showing 165-ton ladle crane.

Salvage is an important consideration. Properly trained labor brings about much saving and the lack of it is very costly. The handling of these materials begins with the operation during which the materials are cast out. Whether the slag goes neatly into the proper containers or flows all over the pit, whether the skulls are unduly large or the spills and "accidents" frequent, whether dismantling is neatly or carelessly done all enter largely into the result. Pit clean-up is a hard job and so as well is the slag yard operation. The magnet for ferrous materials, the grab bucket for slag and refuse, proper provisions for salvaging magnesite, chrome or other refractory and the costly hand shovel (where everything else fails) are the tools of the pit housekeeper. The burning torch and drop ball figure largely. Special large grab buckets and highly efficient crane and motive power service are essentials.

General Problems

Certain special features connected with furnace repair have received considerable attention without particular success. One of these is the removal of accumulations from the slag pockets. Here the fused material becomes a more or less integrated mass that is very hard to break up and loosen. Any method facilitating the removal of this slag without damage to the construction will be welcomed by the open-hearth man, for many hours delay in operations and much expensive labor are now charged to this account. Another is the problem of removing accumulations that clog the checker openings and the handling of the cleanup of this and from the flues. Still another is that of covering the back wall, as previously mentioned, as well as building up the banks under the front wall, both difficult hand jobs.

Different levels convenient for operation necessitate the lifting of materials. Some of this is done by cranes, some by grades on the tracks, some by elevators. Not enough use is made of individual hoists, conveyors, and lifts and not enough attention is paid to provisions for handling small lifts without using regular operating cranes.

If one were called upon to state what is the most important item for improved methods it would not be far from correct to say scrap. But the improvement would be difficult to attain. Handling brick and removing brick bats will, however, yield as much return for the effort as any other single feature, because here mechanization can be applied with good results. However, every item mentioned is a field worth the study of the manufacturer of machinery and devices for materials handling.

World's Largest Steam Pipe Is Arc-Welded

The world's largest steam pipe has recently been completed at the South Philadelphia Works of the Westinghouse Electric & Mfg. Company. It is 7 ft. in diameter and is composed of sections of rolled steel which are joined together by arc-welding. It is to be installed in a large power plant and will carry 1,600,000 lb. of steam per hour at 40 lb. absolute pressure.

Safety from the Viewpoint of Supervision

(Continued from page 1325)

before, my men did not take safety seriously at first but it was not long until they all realized and fully appreciated what we were driving at and they took a very active part toward furthering safety first. With all my men taking this active part in safety it is needless to say that accidents have been almost entirely eliminated and during the past year I have not had a lay-off case in my department.

In closing I want to say that I think we should talk to our men on the job, be careful to see that new men know how to do their work safely and right; and in our talks, go over and over the same safety ideas, told a little differently each time. I am voicing the appreciation of my men and myself for the insistent stand that our company took on the safety question, and I also thank this National Safety Council as the originator of this great move.

Timken Steel and Tube Company

**A Subsidiary Is Formed to Facilitate the Production and Sale
of Bars and Tubing of Timken Quality Steel—
Capacity 30,000 Tons Monthly**

A NNOUCEMENT has just been made by The Timken Roller Bearing Company of the incorporation of a new company, known as The Timken Steel and Tube Company, which will take over the manufacture and selling of Timken steel and tubing. The headquarters and mills are in Canton, Ohio, with sales offices in Chicago, Los Angeles, Detroit, and New York. The officers are: H. H. Timken, chairman; M. T. Lothrop, president; J. W. Spray, vice president; A. J. Sanford, vice president in charge of sales; J. E. Daily, vice president in charge of operations; and J. F. Strough, secretary and treasurer.

The company has been organized to take care of the growing demand for Timken steel among manufacturers of various products, by the production of high grade alloy steels on a quantity basis. Its production facilities consist of the most modern furnaces and mills with a capacity of 30,000 tons of steel per month. This capacity is equally divided between electric and open hearth steels. The mill is equipped to supply any section or size of hot rolled bar stock, or seamless tubing, in any quantity desired. Specialized high grade alloy steels can be produced conforming to any analysis specified, with assurance of absolute uniformity.

Steel Has Special Applications

The use of Timken steel, both bar and tubes, has expanded rapidly over the past few years to include many industries, and diversified applications in each industry. In the automotive industry it is used for gears, axles, connecting rods, and rear axle sleeves. In the oil industry it is used for making bits and jars, and the tubing is used for oil well pump construction. The steel is also used in airplane engine construction, for electric motor shafts, for machine tool parts, and cutting tools, and, in the case of the tubing, for many sorts of mechanical construction.

Equipment for Bars and Tubes

The equipment in the mill has been arranged for straight line volume production from the melting to the finished bars, or tubes. The rolling equipment, together with the necessary reheating furnaces, and additional accessory equipment is unique in several respects. Ingots from the soaking pits go to a 35-in., three high blooming mill and thence to a bloom shear. From the shear the blooms go to a transfer which may carry them to any one of four destinations, the 28-in. mill, the rear of the two 40-ton reheating furnaces, the chipping bed, or the cooling pits. This flexibility permits the routing of all blooms coming from one source to points determined by the subsequent operations they must undergo. Blooms of one type can be rolled directly, without any reconditioning, those of another can be reheated and then rolled, others can be pickled and ground, or chipped before reheating and rolling, and, where necessary they can be cooled slowly, or thermally reconditioned before they are worked further.

Stock going through the 28-in. mill may be delivered to the warehouse for inspection, cleaning, and storage, or to the 22-in. mill for further reduction. Leaving the 22-in. mill, the bars are carried on a run-out table to two hot saws which cut them to the lengths desired for future handling. Before the material coming from this mill is delivered for future operations it is inspected to determine the necessity for further pickling, chipping, or grinding. Cooling pits are also provided for the reconditioning of certain alloys coming from this mill.

Seamless Tubes

Stock intended for fabrication into seamless tubing is delivered to a continuous reheating furnace, from which it is delivered directly to the piercing mill. The equipment used for tube fabrication is also laid out to accommodate straight line production. Stock coming from the reheating furnace is delivered directly to the piercing mill, and thence to the reeler. From the reeler it passes to the reducing mill, which is the final process in reducing to the final sections. This equipment will produce tubing in a variety of sizes ranging from 1½ to 6½ inches O. D. From the reducing mill the tubes pass to a hot bed for cooling before further treatment, such as turning, cold drawing, cutting off, or annealing.

From the 22-in. mill, stock intended for further reduction goes to a 16 stand merchant mill, consisting of three 18-in. two-high roughing stands, five 16-in. continuous stands, two 16-in. three-high, four 12-in. and two 10-in. stands. It is reduced in this mill to a range of sizes from 5/16 to 2½-in. rounds, bars or other sections.

All mills, mill drives, tables and cranes are equipped throughout with Timken bearings.

Treatment and Inspection

Finished stock, tube, bar, or wire, is annealed in a series of eight electric annealing furnaces of various capacities and types of construction. These furnaces, which have been individually designed for the treatment of different types of steels include three 850-kw. pit type furnaces for long cycle annealing, two 700-kw. pusher type normalizing furnaces, one 300-kw. hearth type furnace, two 300-kw. car type furnaces, and four 100-kw. pit type furnaces for treatment of wire stock.

Final inspection of steels is conducted in a building especially provided for the purpose, which also contains warehousing and shipping facilities. This arrangement has been adopted to prevent the possibility of confusion among steels of different analyses, and to expedite shipments. It also enables anticipation of orders from established customers, since it permits the carrying of large stocks of finished material of standard analyses.

Some Problems of the Iron Industry*

The Producer Faces Serious Problems in the Four Items Enumerated—Solution Based on a Readjustment of Ideas to Meet Changed Conditions

By DR. THOMAS T. READ†

THE Lake Superior Mining Institute has a long and honorable record of splendid service to the mining industry of its region, and the degree to which it is appreciated is indicated by the excellent attendance at this meeting. It is quite natural that your institute should have concerned itself chiefly with the many and important problems connected with the mining and transportation of iron ore, and equally natural that the American Institute of Mining Engineers Iron and Steel group which, while new as a division, is old as an important and active group in the work of the institute as a whole, should have concerned itself chiefly with the making of iron from ore, and the subsequent treatment of the metal. The two groups are therefore not in any sense rival organizations, but rather complementary, like the two slices of bread in a sandwich.

I hope this initial joint meeting will be the first of a long series in which an effective co-operation of the two organizations can be developed, for they resemble a sandwich in that some of the most important and difficult problems of the iron industry are common to both. It can be taken for granted that the men of the iron and steel industry cannot permanently prosper unless the industry itself is prosperous, and prosperity for the iron industry does not lie alone in improved technology in connection with the mining and reduction of iron ore and the making of steel, but is seriously affected by many factors which enter from the general field of government and business. Many of you perhaps consider that they are none of your business, but they are because they affect your welfare; anything which affects a man's welfare is most distinctly his business.

Public Appreciation of the Industry

I would put first, because I think that it lies at the base of the problem, the fact that the public as a whole has no real appreciation of the importance of the iron industry in our modern machine civilization. I have often referred to it as the skeleton of our modern civilization, and we are so well aware of the aptness of the simile that we think little of it; but the general public is largely unaware of it. We should all work together to bring about a due recognition of the importance of the iron industry in our national life. We do not want anything that does not belong to us, but we assuredly do want all that belongs to us. That is not an attitude of selfishness, but an attitude of intelligence; for society today is like a machine, every part should have its due importance and perform its due function.

Another problem of the iron industry, which it shares with nearly all the other branches of industry,

*Abstract of speech before the Lake Superior Mining Institute and the Iron and Steel Division, A.I.M.E.

†Secretary, American Institute Mining and Metallurgical Engineers.

though fortunately as yet it is not so acute as some others, is that of control of production. In time gone by the small means of production created little danger of overproduction, and demand was growing as fast as we could provide the means to meet it. But just as the greater speed of the automobile has given rise to traffic problems, that simply did not exist for the old horse and buggy, so the speeding up and multiplication of productive capacity has given rise to economic problems that did not exist before. I will not take the time to repeat here the arguments I have given elsewhere, that some means of control of production are necessary, and we should see to it that the means are provided. It is our work as engineers that has created the problems, and it is our responsibility to see that they are solved and solved right, instead of leaving them to legislators to be attacked from the viewpoint of politics, or to be muddled by economists who resemble the type of "practical" man who was defined as having just as many theories as engineers, only they were mostly mistaken concepts based on imperfect and inaccurate knowledge of the precise data that must govern any sound solution. Just as we do not ask anything that does not belong to us, so we must not shirk any duties that belong to us.

Taxation Functions Against Conservation

Another problem of the iron industry is the incidence of taxation, and its effect on the production of essential raw materials. We hear much talk of conservation, but little discussion of the situation in which we find ourselves where taxation on raw materials is forcing them into production, lest they be eaten up by taxes, instead of permitting them to be held in reserve for frugal use by future generations. We need a searching restudy of the basis of taxation in the light of modern industry. This is a new world we live in, where machines but a decade old are so obsolete that they are fit only for the scrap heap, but we are trying to utilize machinery of government that has scarcely been improved since the time of our grandfathers. We acutely need the engineer in government.

Wrong Ideas in Production

We not only have outworn machinery in society, but we are hampered by outworn ideas; I shall refer to only one, and that is the idea of producing everything as cheaply as possible. For a generation this has been our aim, but already there are many who are questioning whether it is a sound ideal, and everybody knows that a prominent manufacturer who at first had for his ideal the making of his product at as low a price as possible, has scrapped that idea along with much of his existing equipment, and is now aiming at making the best possible product at a reasonable price. I have elsewhere raised the question as to whether iron is not now, and has not long been, too cheap. In scrapping a worn-out automobile, it has been custom-

ary to remove the brass and other non-ferrous metals and throw the iron over the dump as of no value. It seems to me iron is too cheap if it can be regarded as good business to throw it away. The world's supply of iron ore, though large, is limited and, above all, the supply that lies within our country is distinctly limited. Good progress is being made in guarding against loss of iron through corrosion, but to stop rusting, and permit iron in chunks to be thrown away beyond recovery, is saving at the spigot and wasting at the bung. The iron industry may well consider whether it would not be better to aim to make the best possible product at a reasonable price instead of striving always to meet the low price levels that result from our present set-up of industry.

These are only some of the many important problems that affect the prosperity of the iron industry, and therefore affect the prosperity of the men of the industry. They are, therefore, our problems, and we need to hasten to their solution, instead of leaving them to unskilled hands. I hope these two institutes can heartily co-operate in such endeavors to the end that in serving our own interests and the interest of the country as a whole, we may all prosper together.

American Gas Association Laboratory

The new testing laboratory of the American Gas Association in Cleveland, Ohio, was officially dedicated on September 14 when Oscar H. Fogg, president of the association, unveiled a tablet which states that the building "is dedicated to promote and develop the gas industry to the end that it may serve to the fullest possible extent the best interests of the public."

J. G. Clark, engineer of research and training, The London Gas Light and Coke Company, London, England; R. W. Gallagher, president of The East Ohio Gas Company, Cleveland, Ohio; and Carl Shuler, director of law for the City of Cleveland, were the speakers at a special luncheon of more than 100 gas executives and officials held immediately after the unveiling ceremonies.



Laboratory building.

The new laboratory building is a most completely equipped gas appliance and research laboratory, and is also the finest building dedicated to the testing of gas appliances in the world today, R. M. Conner, director, declared in a special interview.

"The building provides roughly 3,200 sq. ft. of office space, 8,700 sq. ft. of storage space, and 14,700 sq. ft. for appliance testing and research," he said.

The building is two-story brick, and was constructed by the Osborne Engineering Company, builders of the University of Michigan Stadium and the Yankee Stadium. Gas is used to heat the building.

It is predicted that the new building will serve as one of the most conspicuous monuments ever erected by the gas industry in the interests of the 75,000,000 users of its service. With the unqualified support of the entire industry, and the co-operation of the U. S. Bureaus of Mines and Standards and the Public Health Service, and other interested groups, we can expect much of the testing laboratory.

The members of the managing committee of the testing laboratory are: R. W. Gallagher, chairman, East Ohio Gas Company, Cleveland, Ohio; R. M. Conner, A.G.A. testing laboratory, Cleveland, Ohio; J. S. DeHart, Jr., Isbell-Porter Company, Newark, N. J.; R. B. Harper, Peoples Gas Light & Coke Company, Chicago, Ill.; N. T. Sellman, Consolidated Gas Company of New York, New York, N. Y.; G. E. Whitwell, Equitable Gas Company, Pittsburgh, Pa.

The British Iron and Steel Institute

In accordance with previous announcements, the autumn meeting of the Iron and Steel Institute, Mr. Benjamin Talbot, president, was held in Bilbao, by kind invitation of the members resident in Bilbao and the neighboring district. The sessions were held at the Assembly Hall of the Alfonso XIII High School, Bilbao, on Tuesday, September 25, at 10 A. M., and on Wednesday, September 26, at 3:30 P. M.

The following is the complete list of the papers presented:

J. Balzola, "Iron Ore Mining in Vizcaya."

C. A. Edwards and T. Yokoyama, "The Influence of Varying Strains and Annealing Temperatures on the Growth of Ferrite Crystals in Mild Steel."

A. Herrero and M. de Zubiria, "The Phenomena of Corrosion of Iron and Steel."

J. Orland, "The Influence of Pearlization Below the A_1 Point on the Mechanical Properties of Carbon Steels."

J. G. Pearce, "The Use and Interpretation of the Transverse Test for Cast Iron."

L. B. Pfeil, "The Change in Tensile Strength Due to Ageing of Cold-Drawn Iron and Steel."

S. H. Rees, "Some Properties of Cold-Drawn and of Heat-Treated Steel Wire."

J. H. Whiteley, "Effects Observed in Quenched Liquid Steel Pellets and Their Bearing on Bath Conditions."

A further discussion of the under-mentioned papers, which were presented at the autumn meeting in Bilbao, will take place in the dining room of the Engineers' Club, Waterloo Street, Birmingham, on Thursday, October 25, 1928, commencing at 4 P. M., with an adjournment for tea at 5 P. M. It is expected that Mr. George Hatton, C.B.E., vice president, will take the chair.

J. G. Pearce, "The Use and Interpretation of the Transverse Test for Cast Iron."

L. B. Pfeil, "The Change in Tensile Strength Due to Ageing of Cold-Drawn Iron and Steel."

S. H. Rees, "Some Properties of Cold-Drawn and of Heat-Treated Steel Wire."

G. C. Lloyd is secretary, who may be addressed at 28, Victoria Street, London, S.W.1.

The POWER PLANT

High Pressure Steam Boilers*

A Review of the Construction Features Made Necessary in High Pressure Steam Generation—Point at Which High Cost Materials Must be Employed

By GEO. A. ORROK†

SOME years ago in a paper presented to the society the author commented on the "Possibilities of High Pressure and Temperature in the Central Station," and came to the conclusion that much higher pressures were a commercial possibility but that we had reached about the limit as to temperatures until constructional materials other than the usual boiler steels were available. In February of this year in a paper before the Midwest Power Conference he presented a list of 40 installations of boilers operating at above 500 lb. pressure, and from the operating results came to the conclusion that the higher-pressure operation was justified from both the thermal and commercial point of view.

It has often been stated that the customary boiler designs which have been found so suitable and satisfactory for the ordinary pressures (150 to 400 lb.) would be at a great disadvantage when much higher pressures were considered and such constructions as the Schmidt, Blomquist, Loeffler, and Benson boilers have been developed to meet the difficulties which the ordinary types presented. In this country the Weymouth and Milwaukee boilers (1200 to 1400 lb.) are a development of the standard types, and the very real difficulties of construction have been overcome by the selection of costly materials and the use of thickness of metal never before attempted in boiler constructions. Münzinger, in his paper at the World Power Congress, investigates the materials and designs of two common types of boilers for various pressures, and stresses the steam accumulator as being necessary with the smaller-water-content sectional boilers. The papers of Hartmann (V.D.I., 1921, No. 26, p. 663, and "Hochdruckdampf" (V.D.I., 1924), Jacobus (World Power Congress), and that of Melanby and Kerr (Proc. I.M.E., 1927, p. 53) bring the discussion of high-pressure steam generation and boiler construction up to the present time. Nevertheless it appears to the author that none of the preceding authors has laid down basic principles, nor indicated the general trend which successful design and construction should follow. This paper is an attempt to bring the problem nearer to solution by suggesting the lines which to the author appear to offer the most promise.

In practice it has been observed that all reasonable boiler designs can be made to operate at a rea-

*Abstract of paper read before the American Society of Mechanical Engineers.

†Consulting engineer, The New York Edison Company.

sonably high degree of efficiency. Boilers of such wide difference in design as the Lancashire type and Babcock & Wilcox type when tested by careful experimenters have developed equally high efficiencies. The design problem then becomes a question of capacities versus costs, and the smallest and lightest design of equal strength and capacity is, within limits, the best commercial proposition. Certain operating desiderata must also obtain. Inspection and cleaning must be easy, circulation must be sufficient, the gases must be brought into intimate contact with the heating surface throughout their course in the boiler, and finally steam-making, superheater, economizer, and air-heater surfaces should be proportioned for the work the boiler is designed to do. From the manufacturing side the parts making up the boiler should be small but not too small, combining light weight with strength (i.e., drawn tubes and cylinders), easily and quickly put together and easy to replace. It is from such considerations as these that the modern water-tube boiler has developed. As a rule these boilers today consist of a steam drum or drums, a nest of tubes connected to the drum directly or by front and back headers of various constructions, and a mud drum. Integral superheaters and economizers may accompany this construction, or a portion of the tube surface may be used for these purposes. The arrangement and the proportioning of the separate parts vary greatly.

In studying the various design of tubular boilers it appears that most of the water content of a boiler is contained in the tube bank, the drums rarely containing as much as 15 per cent of the total water content. In general the weight of water in a boiler with 1-in. tubes will not exceed 0.9 lb. per sq. ft. of heating surface, which increases to about 3.5 lb. per sq. ft. of surface for the standard 4-in. tube and is directly proportional to the internal diameter of the tube. Multiple drums, outside downcomers, large mud drums, and water-wall headers may increase these figures.

Effect of Tube Inclination

Many experiments have been undertaken to determine what inclination of boiler tubes is most conducive to evaporative capacity and efficiency. The Babcock & Wilcox Company after exhaustive experiments with slopes varying from 5 deg. to over 20 deg. have chosen 15 deg. as their standard. The Heine Boiler Company and the Edge Moor Boiler Company use a slope of 4½ deg., approximately, as do

most boilers of the stayed-header type. In the Parker, Belleville, and several other boiler types the slope is nearly horizontal. In the Wickes and certain other boiler types the tubes are nearly vertical, and the Hornsby, Stirling, and Garbe types use all slopes from 45 deg. to the vertical. As a matter of fact, equivalent efficiencies have been obtained with tubes of practically all degrees of slope.

Circulation

In shell boilers the circulation problem is quite serious, and many troubles have developed from this source, resulting in the introduction of mechanical aids to circulation such as the hydrokineter, but with the water-tube type these difficulties do not appear to be of much moment.

We may take it as a fact that with water-tube boilers, circulation may be rapid or sluggish, depending on the arrangements which the designer has used, and that the more nearly the boiler approaches the flash type, the slower is the circulation. As a corollary to this conclusion we can state that the water content of a boiler and the necessity for speed in circulation increase with the departure in type from the flash boiler and must be at their maximum in a shell boiler. Münzinger and other authorities agree with Albans that the size of the steam bubbles and therefore the percentage of vapor in the tubes decreases with increase of pressure. His curves show that the percentage of solid water increases largely with the pressure—thus the circulation at high pressures may be more sluggish without detriment to boiler operation—and this leads to the Benson contention that the best results should be obtained at the critical point (3200 lb.) where steam and water have the same density and therefore no bubbles exist and no line of demarcation can be drawn between water and steam.

Releasing Surface and Steam Space

It is usually stated that there must be a water surface of sufficient area to release the steam bubbles from the water to prevent priming, and that a steam-storage space must be provided to allow the water particles not evaporated but entrained in the steam to settle out. The usual allowance for steam space in a shell boiler is about one-third of the volume, and the ratio of heating surface (HS) to releasing (RS) is $HS/RS = 3.5$. This ratio in the ordinary return tubular boiler is 17, in the standard three-drum 14-high 21-wide Babcock & Wilcox is 31, in the Babcock & Wilcox cross-drum type, 96, in the Connors Creek Stirling, 71, and in the boilers of the Almy, Ward, and Belleville types, from 2000 to 7000. As all of these boilers prime occasionally and all can be run without priming, it will be seen that releasing surface has nothing to do with priming. As a matter of fact, priming will not occur unless the boiler is impure or soapy due to the presence of colloids. Entrained water is a different thing and will occur in all boilers to a greater or lesser degree, depending on the location of the tubes entering the drum and the dry-pipe arrangements. Efficient dry pipes are an essential part of all boilers, and the greater capacity (higher rating) obtained requires a better and more liberal design of dry pipe. Steam domes and steam drums in addition to the ordinary drum have been used to assist in obtaining dry steam. Superheaters should not be used for evaporators, and the releasing

surface should be such that particles of water under maximum conditions should not reach the dry pipe.

The steam-space ratio (HS/SS) also varies largely—from about 4-in. shell boilers, 22.5 in the longitudinal-drum Babcock & Wilcox, and 50 in the Babcock & Wilcox cross-drum to over 100 in the Belleville and 150 in the Ward, and was very large in the earlier Belleville boilers and almost infinity in the Herreshoff coil boiler and other flash boilers. All of the high-ratio boilers made special provisions for feedwater regulators and safety valves, and these features appear to be necessary for operation.

It should be noted that either a time element (i.e., steam-storage space) or pressure reduction (i.e., throttling of the steam) appears to be necessary to good running. In the drum types the steam must rest for a short time before entering the dry pipe, while in the Almy, Belleville, and coil types the steam nipples connecting the boiler tubes to the steam drum or dry pipe are extremely contracted in area, so that there is a large pressure drop and consequent drying or superheating of the steam. Similar action takes place in the passage through superheaters, and in many boiler types the steadiness of steaming is greatly enhanced by this effect.

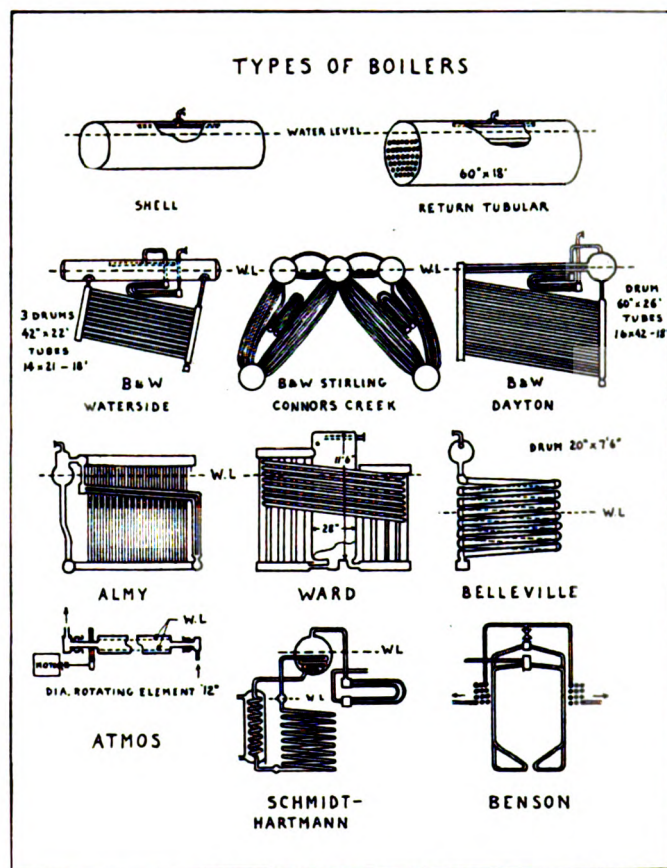


FIG. 1—Types of boilers.

The earlier boiler builders understood these facts very well. Watt, Albans, and Bourne allowed from 8 to 10 sq. ft. of heating surface per cu. ft. of water evaporated per hour. This corresponds roughly to 200 per cent of rating (6.25 lb. to 7.8 lb. evaporated from and at 212 deg. per sq. ft. of heating surface). Their rule for releasing surface was 5 sq. ft. per cu. ft. of steam per sec., which corresponded to 37 sq. ft. per 1000 lb. of water evaporated per hour in the at-

mospheric boilers of Watt. At 200 lb. gage the figure is roughly 3 sq. ft. per 1000 lb. per hour while at 1200 lb. the surface is 0.5 sq. ft. per 1000 lb. evaporated per hour. Considering the 200-lb. boilers (in Table I) the 3 sq. ft. per 1000 lb. per hour is 5 cu. ft. of steam per sq. in. of releasing surface per hour. The table shows normal values of 10 times this ratio at 100 per cent of boiler rating. On the actual maximums, 20 to 30 times the early figures are shown. DeLaval and Serpollet, working at or above 1000 lb. per sq. in., had no trouble from lack of releasing surface or steam-storage space. The Serpollet steam and water passages were $\frac{5}{32}$ in. wide, and the water contents very small indeed. Boilers with tubes as small as 1 in. O.D. work very well in quite large sizes, but 2 in. is about as small as has been used to any extent in land practice, although Yarrow used $1\frac{3}{4}$ -in. tubes in the Dunstan and Barking boilers. The Almy boiler has a ratio one-twentieth as large, while the Ward and Belleville boilers have a releasing surface only about one-hundredth as large as Watt's standard. These two types have very restricted circulation and the releasing surface is in the tube, but they were able to carry heavy loads without serious entrainment troubles. Many boilers have been operated at 150 cu. ft. of steam per sq. in. of releasing area per hour, or a steam velocity leaving the water surface of 6 ft. per sec., and a simple calculation will show that at this rate the tube area itself furnished ample releasing area. This same calculation will show that a 4-in. water-wall tube 70 ft. long will have sufficient releasing area in itself if the water level is carried in the tube, a fact which has been a stumbling block to some designers. Similar calculations also show that conditions improve with increase of pressure.

Watt and Bourne allowed a volume of 20 times the high-pressure cylinder for the steam space. At the steam speeds in vogue at that time this allowance was equivalent to about one minute's storage in the steam drum, but this rule was not followed and ratios of (HS/SS) instead of being 4 were of the order of 12 to 16 as in our return tubular boilers. Since the invention of the turbine, intermittent-flow troubles have ceased and the ratio may be much larger.

In general, because of the lower specific volume, high-pressure steam needs much less releasing surface and steam space than low-pressure steam. Boilers should work much better at high pressure, and much less trouble is to be expected with increasing pressures.

Safety in Operation

As a general rule, that design is the safest which has the smallest volume of water content, since "superheated water" is the chief source of danger in a boiler; therefore drums should be made as small in diameter as possible in order to avoid this danger. The tearing of drum sheets, so common in explosions of low-pressure boilers, allowing large volumes of superheated water to flash into steam, should not occur in high-pressure work. It has been observed by all operators of high-pressure boilers that split tubes or bulges which open do not lead to explosions. In many of the cases reported the fact of the split tube became known only by the extinguishing of the fire, the slight hissing noise not having been noticed by the operator until after the fire had been extinguished.

The most important development in boilers in the twentieth century is the great increase in capacities

which are now being secured from all types of modern boilers. Improvements in furnaces, water-cooled furnace walls, and combustion control, and the introduction of powdered coal have enabled the boiler operator to increase greatly the 7 lb. of water evaporated per hour per sq. ft. of heating surface recommended by Watt, which had been cut in half by the Centennial Boiler Testing Committee. Fifteen to twenty pounds at good efficiency has now been secured, and 25 to 30 lb. is in sight. This condition exaggerates an operating difficulty more or less common in earlier boiler plants, namely, the "loss of water" or the lowering of the water level in the boiler drum below the gage-glass level when the forced draft failed or the coal feed was interrupted in the powdered-coal installations. In most modern boilers less than 15 per cent of the water is contained in the drum, and when steaming at a high rate more than 20 per cent by volume of the water is steam bubbles. As long as the operation is continuous no troubles are encountered, but in an emergency when the coal feed is interrupted or the forced draft is cut off the bubbles are absorbed and the water contracts rapidly, the water level falls, and the automatic feed regulators open wide, filling up the drum. When steam making starts, the volume increases, the water level rises, water enters the dry pipe, and slugs of water may pass through the superheater and steam mains with serious results. In flash boilers above 600 lb. pressure this difficulty is not of much moment, but at pressures from 200 to 600 lb. and high ratings as much as 40 per cent contraction may be encountered and the water level brought well down into the tube body. This has always been considered a dangerous condition, even though it is well known that Manning and other vertical fire-tube boilers carry the water level much below the tube tops, and all flash, coil, Belleville, Ward, Thornycroft, and some other water-tube boilers have the water level somewhere in the tube bank. To prevent siphoning over the auxiliary steam drum, multiple drums as in the Borsig and similar designs or an increase in the size of the main steam drum will obviate the difficulty. The latter two devices do not appear to be good practice, since they increase the water content and multiply the sources of danger from superheated water. A number of methods of working the feedwater regulator have been suggested which can take care of this condition in a better and easier way, and such devices are being developed. It is also a question whether a dropping of the water level into the tube bank of high-pressure boilers is a dangerous proceeding. To the author such a procedure is much less of a menace than an additional drum with its content of superheated water.

Boiler Materials

As an appendix to the paper on high pressures and temperatures before referred to, the author gave a résumé of the knowledge then available on the variation of strength of boiler materials with temperature. This body of facts has been largely augmented and the newer theories of fatigue and creep have been developed. Fatigue phenomena are apparently reasonably consistent, and only rarely enter into the boiler problem. Creep phenomena, on the other hand, are still highly controversial, some authorities holding that creep does not occur below certain limited stresses which may be well above the limits of proportionality. The opposing theory that creep occurs at

all temperatures and stresses and that the condition must be chosen to limit the creep to safe values over a period of time, is also strongly held. Mellanby, Lea, Tapsell, and others in England and France, and Lynch, Malcolm, McVetty, White, and others in America, have presented excellent papers in which the known facts and theories have been ably discussed.

Temperature Margins

Mellanby and Kerr in their 1926 I.M.E. paper showed excess temperature margins in boiler, water-wall, and superheater tubes, from which they drew the conclusions that the temperature margin with the ordinary boiler steels was too small and that the use of alloy steels was indicated when higher pressures and temperatures were to be used. They developed formulas for and calculated heat strains in addition to the pressure strains in the body of the tubes. Their figures are made on 0.35 C steel, while the author's are on 0.12 to 0.15 C National Tubes Company's steel. Comparative temperature margins on 4-in. boiler tubes at 108,000 Btu. absorbed per sq. ft. per hour are as follows:

	Pressures			
	200 lb.	600 lb.	1000 lb.	1400 lb.
Mellanby	420 deg.	275 deg.	180 deg.	120 deg.
Orrok	480 deg.	300 deg.	200 deg.	100 deg.

From experience obtained with different boilers at high and low-pressure stations both here and in Europe it would appear that a 200-deg. temperature margin is safe for all ordinary work, particularly as 100,000 Btu. per sq. ft. per hour is above the maximum ever obtained in any of the experiments except the plate experiments of Witz and Nicholson, which do not represent boiler conditions. The experiments of Witz are very interesting since the point of the inner cone of the Bunsen flame which he used impinged on the surface of the plate, a condition similar to the blowpipe action shown in a forced-draft installation with small holes in the fire bed. When the flame point touched the tubes the outer surface of the metal became red hot and resulted in local bulging or a split tube. The flame temperature at the point of the inner cone is of the order of 3000 deg. F. or higher, and this action was well known as far back as Alban's time. The temperature of the outer cone is much lower, but in all cases the flame should not impinge directly on the tube surface. The absorption of radiant heat is usually sufficient to reduce the gas temperature to a safe figure. In this connection it is instructive to note that high-pressure tube failures, i.e., explosions, invariably occur in very limited areas and usually make themselves known by putting out the fire. The openings are usually very small, and probably the higher velocity at the point induced by the outflowing steam introduces sufficient cooling action to prevent the spreading of the opening.

TABLE I—Data on Modern Boilers.

Types of boilers and drum sizes	SS Steam space, cu. ft.	RS Releasing surface, sq. ft.	HS Heating surface, sq. ft.	HS/ RS	HS/ SS	Weight of water in boiler, lb.	W/ HS	W Water evap'd. per hour, lb.	Time to evap. boiler cont. min.
Steam Pressure, 200 lb. per sq. in.									
Belleville (S.S. Charlemagne), 20 in. × 7 ft. 6 in., 7 elements, 16 tubes	16.5	0.61*	1,800	2950	109	3,500	1.95	14,220	14.7
Ward (U.S.S. Monterey)	18.0	0.45*	2,970	6670	165	5,360	1.81	20,100	16.0
B. & W. (U.S.S. Cincinnati), cross-drum 42 in. × 12 ft.	58	42	2,640	63	45.5	9,480	3.59	30,760	18.6
Stirling (Conners Creek), two 48 in. and 154 in. × 28 ft.	576	350	25,000	71.5	43.4	66,000	2.64	149,600	26.5
Almy, 66, 1¼-in. tubes	37	0.47*	1,386	2950	37.5	1,850	1.34	3,230	34.0
B. & W. (Dayton), cross-drum 60 in. × 26 ft.	255	130	12,500	96.3	49.0	84,240	6.75	91,200	55.4
B. & W. (Waterside), three 42 in. × 20 ft.	288	210	6,500	31	22.5	51,210	7.88	54,900	56.0
Return tubular, 60 in. × 18 ft., 125 bhp.	70	76.5	1,250	16.6	17.9	16,100	13.4	5,620	171
Steam Pressure, 250-400 lb. per sq. in.									
Ladd (Fordson plant), 7-drum 60 in. × 27 ft., 54 in. × 28 ft., 36 in. × 25 ft.	1151	522	29,500	56.5	25.6	206,000	7.0	97,000 460,000†	128 27
B. & W. (Colfax), cross-drum 60 in. × 33.7 ft., 20 × 47 tubes	330	165	29,780	181	90.5	113,000	3.8	98,000 300,000†	69 22.5
B. & W. (Gould St.), cross-drum 60 in. × 32.8 ft., 18 × 51 tubes	321	161	29,070	181	90.5	106,000	3.65	104,000 416,000†	61 15.3
B. & W. (Stanwix), cross-drum 60 in. × 33.7 ft., 20 × 51 tubes	330	165	32,070	194	97.0	119,000	3.72	105,000 300,000†	68 24
Springfield (Hell Gate), cross-drum 54 in. × 29.5 ft., 16 × 54 tubes	235	133	13,900	104	59.2	70,000	5.04	225,000	18.7
Springfield (East River), cross-drum 54 in. × 29.5 ft., 16 × 54 tubes	231	133	17,830	134	77.2	103,000	5.78	350,000	17.7
High-Pressure Boilers, 1200-3200 lb. per sq. in.									
Atmos., element, 12 in. × 15 ft.	3.0	23.5	47	2	15.7	425	9.1	2,500	10.0
Schmidt-Hartmann (SHG), 36 in. × 10 ft. 10 in.	20.7	29.0	283	9.8	13.7	2,320	8.2	3,300	42.0
Benson (SSW)			1,850	8	8	680	0.37	66,000	37 sec.

*Water level in tubes.

†Evaporation at 100 per cent of rating and maximum evaporation.

Stresses in Superheater Tubes

Convection superheaters show very low heat-transmission rates, the maximum reported being about 6000 Btu. per hour per sq. ft. for a straight convection superheater, which has only been increased to 8,000 to 9,000 for the usual interdeck variety. Steam velocities must not fall below 40 to 50 ft. per sec. or the temperatures of the outer and inner surfaces will equalize and tend toward the gas temperature. This fact was well-known very early, and was the reason for flooding during the warming-up period. For standard conditions in convection-type superheaters (750 deg. F. total temperature) the temperature margins are of the order of 400 deg. F. for 200 lb., and around 200 deg. F. up to 1,400 lb. This figure has been calculated for a heat transfer of 10,000 Btu. per hour per sq. ft. Radiant-heat superheaters suffer much more severe punishment since the transfer rates may be as high as 60,000 to 70,000 Btu. per hour per sq. ft. although the highest reported rate is around 30,000 Btu., and the tube is frequently exposed to the flame tips, both inner and outer, as well as to direct radiation. Temperature stresses play a very important part, and the total stress is about twice that occurring in a convection-type superheater for the same pressure. The temperature margin has been reduced to 250 deg. F. at 200 lb., is only 200 deg. at 500 lb., and 100 deg. at 1,200 lb. Under these conditions the life of the superheater tubes must be much shorter, and bulges and failures must occur at short intervals with comparatively low pressures. Flooding is dangerous even at the lower pressures, and would probably not increase the life of the superheater tubes materially. No attempt has been made, so far as is known to the author, to increase steam speeds to the point where the 200-deg. temperature margin could be maintained. In general, with ordinary boiler material radiant-heat superheaters are much more subject to troubles than the usual convection type.

Conclusions as to the Best Type of High-Pressure Boiler Under Present Limitations

We may now state our conclusions as to the type of high-pressure boiler best suited to our present limitations.

1—Very high-pressure boilers (2,000 lb. and over). Flash type, tubes 2 in. or less in diameter, no header, no drums, all welded points, except at collectors and manifolds where flanged or coned joints should be used. These boilers consist of a single coil for small outputs or multiple coils as in the Benson boiler.

2—High-pressure boilers (800-1,600 lb.). Water-level type, consisting of a bank of tubes of larger diameter than those indicated for the flash type, with walls not to exceed one-tenth of the outside diameter in thickness. Tubes to be expanded in headers or small diameter drums whose thickness when exposed to fire should not exceed one-tenth of the outer diameter. Water-line drum should not contain when half-full more than 10 per cent of water content of the boiler. The boiler should be high rather than low, so that the water in the tubes may be under sufficient static head to insure steadiness of steam, and restrictions in discharge opening to steam drums should be sufficient to obviate serious moisture in the steam. Dry pipes or separators should precede the superheater. Steaming economizers should not be used, but the feedwater should be heated by economizer or the regenerative system so that little water heating

is left to be done by the boiler itself. Water-cooled furnace walls should be used in sufficient amount to make the furnace repairs a negligible quantity.

3—With temperatures in excess of 750 deg. F. we must be content with a shorter life of tubes and be prepared to replace coils or tubes from time to time. The only alternative is the use of much-higher-cost alloy steel.

International Combustion Acquires Hedges-Walsh-Weidner Company

George E. Learnard, president of the International Combustion Engineering Corporation, announces one of the most important acquisitions in the history of the company. Negotiations have been completed for the purchase of the Hedges-Walsh Weidner Company of Chattanooga, Tenn., a recent combination of The Casey-Hedges Company and The Walsh & Weidner Boiler Company, two of the oldest and most widely known boiler manufacturing companies in the United States.

With this new company, International Combustion acquires a large and general boiler business, and augments its present extensive manufacturing facilities with two of the most modern boiler plants in the country, one of which is an outstanding factor in the sectional header boiler field, and the other has facilities for the manufacture of the largest drums which can be made in the United States. This most recent acquisition is in keeping with International Combustion's policy of expansion along sound economic lines by the acquisition of going units of high standing, whose business fits in with the company's policy of completely covering the fuel burning and steam generating field.

Combustion Engineering Corporation's present line of boilers, augmented by that of the Hedges-Walsh-Weidner Company, makes it possible for Combustion to offer any type of boiler, large or small, now available on the American market. This diversity of boiler equipment, supplemented by Combustion's already complete line of fuel burning equipment, enables the company to install steam generating plants of all types and sizes—complete from coal bunker to ash pit—on one contract, with the important advantage to the purchaser that he may place responsibility for the satisfactory performance of the complete plant with one organization.

The acquisition of the Hedges-Walsh-Weidner plants is of particular importance to Combustion at this time as the plants provide manufacturing facilities of sufficient size to build large units.

The Hedges-Walsh-Weidner reputation for quality workmanship and precision methods (extremely necessary to this type of specialized work), was the basic reason for the negotiations leading to the purchase. From an economic standpoint, the acquisition is as important as from the mechanical, as the economies made possible through the consolidation of these properties under the one management will readily and immediately accrue not only to the benefit of Combustion, but also to the field it serves.

The new acquisition will function in all phases of its activity through Combustion Engineering Corporation, the American operating subsidiary of International Combustion Engineering Corporation.

Metals for Blades of Steam Turbines*

Discussion of the Relative Merits of Alloys with Different Proportions of Chromium and Nickel—Test Results
Cited and Conclusions Drawn

By ALBERT BODMER†
PART II

AFTER referring briefly in Part I of this article† to the bronze and brass reaction vanes of early turbines, other blading metals were reviewed. Alloys such as nickel brass, copper nickel, and nickel copper were spoken of, and their physical and corrosion-resisting properties discussed in relation to the high temperatures prevailing in modern turbine design. Steels alloyed with 5 per cent of nickel and their behavior as blading metal were described and illustrated, also steels with high proportions of chromium and small nickel content. In considering the commonly called "stainless" and "rustless" steels containing 13 per cent of chromium it was pointed out that the relative inoxidizability of these steels is connected with the state of surface polish, and that if erosion attacks and removes the polish, the resistance to corrosion relaxes. We have now to consider materials alloyed with high nickel and chromium contents.

Alloys with High Contents of Nickel and Chromium

The alloy A.T.V. has been studied, and was introduced some 12 years ago at the Imphy Steelworks (Société de Commentry-Fourchambault et Decazeville). It is a ferro-nickel chromium with high contents of nickel and chromium, the proportion of this latter element having been calculated so as to stabilize the ferro-nickel with 36 per cent of Ni, certain features of which would be worth preserving, but which becomes spoiled in water vapor, as recorded. The author in 1916 had experience of this alloy in connection with a steam turbine constructed at Belfort, when engineer to the Société Alsacienne. In the same year, at the Missiessi Central Station of the Toulon Arsenal, fixed blades with 5 per cent nickel had given trouble, and it was suggested to the Navy Department to replace the defective blades by others in inoxidizable metal. At that time, unfortunately, it was impossible to obtain in the time available the necessary quantity of metal, and it was only in 1920 that the replacement could be carried out. Abstracted here is the opinion of M. Metenier, chief engineer of the Navy (France).

The rapid deterioration by oxidation of turbine blades when the blades are in oxidizable steel is well known.

The oxidation is favored, in certain cases, by the following causes:

- 1—Condensation of sea water. In spite of all precautions taken to prevent the entry of sea water to the condenser, and keen supervision by a salinometer of the condensed water, the introduction of small quantities of sea water cannot be prevented. The obnoxious influence of chlorides is well known.
- 2—Lack of tightness in stop-valves, which allows the filtering in of a little steam, favoring oxidation.
- 3—Communication of the turbine with the moist condenser during the whole duration of the stoppage of the turbine.
- 4—The wheels where the pressure approximates to atmospheric pressure are those which oxidize most rapidly.

*From World Power.

†Membre de la Société des Ingénieurs civils de France.

‡Blast Furnace and Steel Plant, September, 1928.

At the Central Power Station of the Toulon Arsenal the blades lasted from four to five years, but long before the replacement of the blading was demanded by mechanical considerations, the wearing away of the edges, and deep holes, seriously interfered with the working of the turbine.

The plant consists of four turbo-alternators from the Société Alsacienne with Zoelly turbines, and is subject to an essentially discontinuous operation, owing to its connection with a large hydro-electric energy supply from the Mediterranean littoral. Reheatings there are extremely numerous.

Blades—After the first repairs to the blades, it was decided to undertake trials with new steels. But the war period thwarted experiments, and moreover, previous trials made elsewhere on steels with high nickel content, and less oxidizable, had led to disappointment, owing to the alteration in these ferro-nickels under the action of steam. The problem was especially important as regards the guide blades. These are cast into the discs, and when they become perforated it is necessary to replace the complete discs. The rapidity with which a directing ring becomes pierced is also well known. When this happens, the steam, passing through the hole, proceeds to perforate the following one, and the ring is destroyed in a very short time. The reblading of moving wheels is, on the contrary, much more convenient and less costly.

The first trials were carried out near the region of atmospheric pressure, on the directing rings, of 2,400-hp. turbines. These rings in A.T.V. steel have been in position and in service since August, 1920. They are still intact at the present time. When the reblading of a 3,550-hp. turbine became due, it was decided to make a trial of the steel for the guide blades and also for the low pressure moving blades which were worn; that material was put into position in 1922. At the last recent opening of this turbine, all these blades were intact.

This steel up to now has been high in price, and that is one reason which has prevented us from proceeding more rapidly with its general use for all parts of blading. At the same time, as we have shown, prudence was essential in the matter of tests on appliances of such importance, with materials containing a high proportion of nickel. However, actually we consider the experiment is conclusive, and there must be no hesitation in utilizing inoxidizable steels for turbine blading.

Packing springs—Another similar problem arises: in turbines the tightness of packings and of directing rings on the shaft is often made by means of fittings of carbon, maintained by springs resting in a groove on these fittings. In one case these springs lasted about six months. At the end of that time they had lost all elasticity, and if left in position broke rapidly. The fittings left to themselves also broke, and the packings seized. As regards the internal fittings of the turbine, they were never found. The turbine without doubt consumed them, but not without damage (warped vanes and vibrations). Trials of nickel-plating, tinning, and copper-plating had been attempted on instructions from the builders, but without success. Then again, we decided to try inoxidizable steel and obtained springs in A.R.C. steel and afterwards also in A.T.V. Good results were immediate, but after a certain time, fractures of the springs occurred at certain points. These springs, however, were intact in the portions not in contact with carbon, and had retained their elastic properties perfectly. That was an advance, but not sufficient. Micrographic examination showed that at the contact between the spring and carbon, erosions were formed similar to those produced by an electrolytic effect.

The exciter and rotor of the alternator were thoroughly insulated, but it is known that currents in the shaft may arise from dissymmetries in the field of the alternator. It was necessary to try and break the contact between the springs and the rings. A series of tests were made on this point, but the best results were obtained by applying a wash of insulating material to the grooves in the carbon packings. The springs themselves were dipped in the insulating mixture. No cavity in the

springs has been observed in either of the steels. On the high pressure side the insulating mixture is cracked, but has continued to fulfil its insulating functions since the springs are intact. Four years' experience in the use of the inoxidizable steels has solved the problem of oxidation in turbines in a very satisfactory manner. The results obtained permit foreseeing the development of the use of alloys with high percentages of inoxidizable nickel and chromium, with stable mechanical properties, the cost price of which will be reduced by larger output. These alloys solve the problem of inoxidizability in a more complete manner than 13 per cent chromium steel likewise used. In any case it would seem essential to require the use of inoxidizable, or at least only very slightly oxidizable, metals in the construction of marine turbines, or land turbines having a condensation of sea water.

Tests

Since 1919 tests of the erosion and corrosion of different metals of French manufacture were made by the author. In these tests blades of normal profile were placed in pairs in front of a nozzle and submitted over several days to a jet of slightly humid steam,

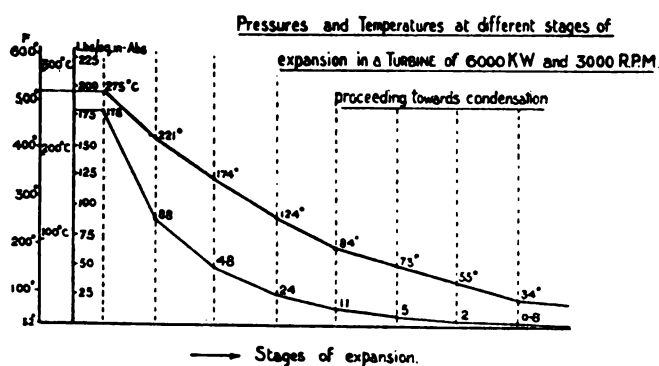
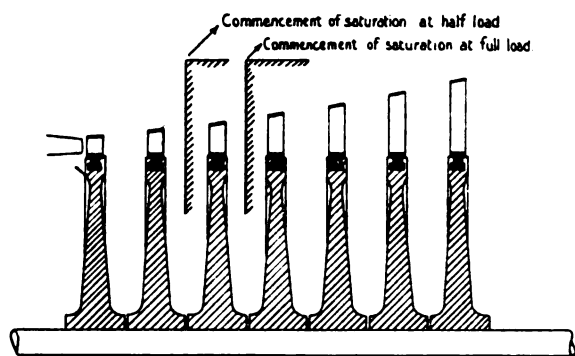


FIG. 7

with a velocity of 2,950 ft. per second. These results led many constructors to develop little by little the use of this steel in the blading of turbines, moving as well as fixed, whenever corrosion and erosion were to be feared. The alloy referred to lends itself particularly to the construction of fixed blades of the directing rings of turbines. As has been said previously, the blades of these directing rings have their extremities cast into cast iron. As a result of the casting, the temperature at the extremities of the blades, and even over the whole of their extent when their dimensions are small, is very high; notwithstanding this there has never been found either a change in the mechanical properties nor brittleness. The micrographic appearance is not modified. The blades of the directing rings after casting conserve entirely their resistance to erosion and corrosion.

The adhesion of cast iron to blades of A.T.V. steel is superior to that of other metals, and has been es-

tablished by test. The author recollects a recent experience in which 13 per cent chromium steel and this alloy were under comparison at the Central Station of Gennevilliers. In the order for two groups of 50,000-kw. turbines it was required of the contractors to construct the fixed and moving blades in all the stages from inoxidizable metals. One of them adopted the alloy—the other employed for the high pressure 13 per cent chromium steel, for the medium pressure and for the first stages of the low pressure, brass; and for the final stages of the low pressure, 13 per cent chromium steel hardened by thermal treatment after the formation of the blades.

These machines have been in service about a year. The blades are entirely in a perfect condition in the unit bladed with the alloy. This machine when last opened up for examination had functioned about 2,700 hours without any corrosion or erosion having been observed. Often the temperature of the steam, normally from 370 to 380 deg. C. on admission to the turbine, exceeded 400 deg. C. The vacuum obtained during the cold periods was about 98 per cent of the atmospheric pressure, which, for a thermo-dynamic efficiency of 82 per cent, indicates a humidity in the steam of about 12 per cent on its exit from the final stage.

With the other machine, after less than 1,500 hours' working, the following observations have been made: at the high pressure, where the fixed and movable blades are of 13 per cent chromium steel, many moving blades have been found more or less strongly notched; many rows of the stages have had to be replaced. The blading of the medium pressure in brass was found in perfect condition, except some fixed and movable blades slightly deformed by the particles of metal detached from the notched high pressure blades. The movable blades of the final low pressure stages were found strongly eroded and slightly corroded. As has been mentioned previously, the erosion which is produced at the back of the entry edge of the blade is convincing proof that the attack was caused by droplets of humidity carried by the steam. The conditions of working of this machine are the same as for the first.

The alloy under review has proved itself unalterable in water vapor under the most difficult conditions: high pressure, high superheating temperature, high circumferential speed, long stoppage of machines, impure steam contaminated by sea water owing to leakages in the condenser. It has not, like 13 per cent chromium steel, a simple surface resistance to corrosion; its unalterability is quite independent of the state of the surface polish and heat treatment, intentional or otherwise, undergone by the metal. The alloy is, moreover, a strongly austenitic metal, which does not change its nature under the influence of heating followed by cooling. This explains the retention of the primitive micrographic appearance in the vanes of fixed blades which have their ends embedded in cast iron during the casting of the rings. Another example of the behavior of blading of the steel is the following: Fig. 7 shows the diagram of pressures and temperatures at different stages, to the number of seven, of a turbine of modern construction of 5,000 kw. at 3,000 revolutions per minute. This machine is fed by steam at 200 lb. per square inch at 300 deg. C., the maximum temperature in industrial operations having often attained 360 deg. The vacuum at the exhaust opening

has reached during the cold period 96/96.5 per cent of the atmospheric pressure. At full load it is at stage number four, where the steam passes from the superheated to the saturated state; the blades of this row are consequently the most exposed to oxidation. Fig. 8 shows the blades of this stage; they are of 5 per cent nickel steel, the attack by oxidation is already serious, and their replacement will be necessary in a comparatively short time. Fig. 9 shows the blades of the last moving row. These had been made in A.T.V. alloy so as to resist better the erosion and corrosion. These blades are absolutely intact and like new; no corrosion or erosion has been noticed; on the contrary, it is clearly seen that the disc of the moving wheel is slightly oxidized, as also are the rivets fixing the blades into the rim of the wheel. When these photographs were taken, the turbine had been 6700 hours in operation with numerous stops of short duration. The mean power was almost always about 4,000 kw., rather more than three-quarters of the full load.

In an article by Mr. L. Daniel* on the corrosion and erosion of blading metals the question of steam penetration into stationary turbines was referred to. When steam is allowed to penetrate into a turbine at first it becomes condensed on the blades, and there is risk of oxidation of the metal. Also in the event of the boiler feed-water accidentally containing dissolved salts, there may be chemical attack of the blading by the decomposition products of these salts. It is to avoid such corrosion that inoxidizable metals are utilized for turbine blading. Among these there is occasion to mention, in the first place, brass, which is most easy to work, but which, unfortunately, cannot ordinarily be used either in the high pressure portion, by reason of its brittleness in high temperature steam, or in the low pressure, owing to its elastic limit, which is too low for the fatiguing duty imposed in this portion of the machine. Mention may also be made of the "stainless" kinds of steel which contain 12 to 14 per cent of Cr. These steels are not absolutely inoxidizable, but less oxidizable than ordinary steel under certain conditions of attack, and particularly in moist steam. Their mechanical characteristics give full satisfaction, provided that they have been suitably heat treated, but this treatment is delicate. Lastly, alloys containing a fairly high proportion of nickel can also be used, such as Monel metal or A.T.V. These metals are inoxidizable owing to their constituents, and the mechanical characteristics, correspond with those for the most heavily loaded bladings.

One must mention that the cases of chemical attacks mentioned above are abnormal, especially in modern power stations where the causes of these risks cannot exist if ordinary precautions are taken in operation. Mr. L. Daniel, who at that time was chief of department of mechanical construction in the Cie Electro-Mechanique, does not consider it indispensable, in spite of the tendency which now seems to show itself, to furnish all the turbines in large power stations with bladings in inoxidizable metals, especially in view of the price of these special metals being much higher than that of 5 per cent nickel steel, which has been used up to now.

There is another view, however, concerning the utility of furnishing modern turbines with bladings in inoxidizable metals. In an important electrical supply

station it was undecided as to the kind of metal to be used for construction of the blading for a turbine to be ordered. According to proposals of the builders, the addition to the price for blading the turbine completely in A.T.V. steel instead of 5 per cent nickel steel, was 270,000 francs. This figure was considered too high, and it was finally ordered with blades of 5 per cent nickel steel. The first consumption trials were made one month after starting up; a second series of

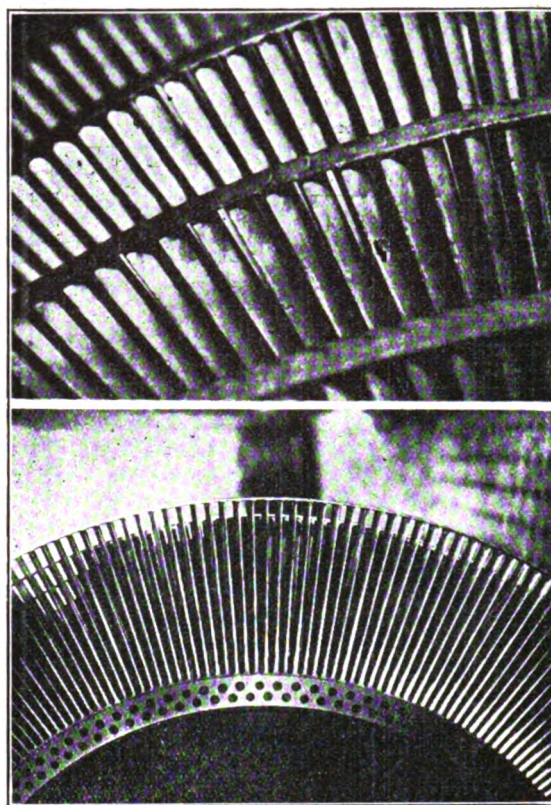


FIG. 8 (upper)—Blades of 5 per cent nickel steel in a 5000-kw. turbine at 3000 revolutions per minute after 6700 hours in operations. FIG. 9 (lower)—Blades of A.T.V. steel in a 5000-kw. turbine at 3000 revolutions per minute, after 6700 hours in operation.

trials were made after 4,800 hours' working: the increase in consumption, i.e., the decrease of output, was 2.1 per cent. After 10,900 hours of running, a third set of trials was made, and the yield was found lower by 1.9 per cent than that of the second series, viz., a drop of 4 per cent. The turbine was dismantled and there was found to be a slight corrosion on the medium pressure blades, and very strong erosion on the last three low pressure stages, to such an extent that the replacement of the last two stages was considered indispensable.

Physical Characteristics of A.T.V.

This metal is used just as it is supplied by the steelworks, and without any heat treatment. Its working up is scarcely more costly than that of 5 per cent nickel steel. It lends itself conveniently to being drawn and flanged, and this is adapted to all the methods of blade manufacture. In general it is supplied in the soft condition, obtained by heating to 950 deg. C., followed by cooling in air or in water. In this condition its mechanical characteristics (Fig. 10) are in fact of particular regularity, viz.:

*"L'Action industrielle et commerciale," May, 1928.

Tensile strength	39 tons per square inch
Elastic limit	20 tons per square inch
Elongation	25 per cent

In cases where a different elastic limit is required, for example the largest wheels of turbines, this alloy is used in a non-softened condition with an elastic limit as high as may reasonably be required, for example 25 tons to 29 tons per square inch. The tensile strength and elongation are practically the same, as also the aptitude for machining. At a temperature of 400 deg. C. the characteristics are practically the same as at ordinary temperature.

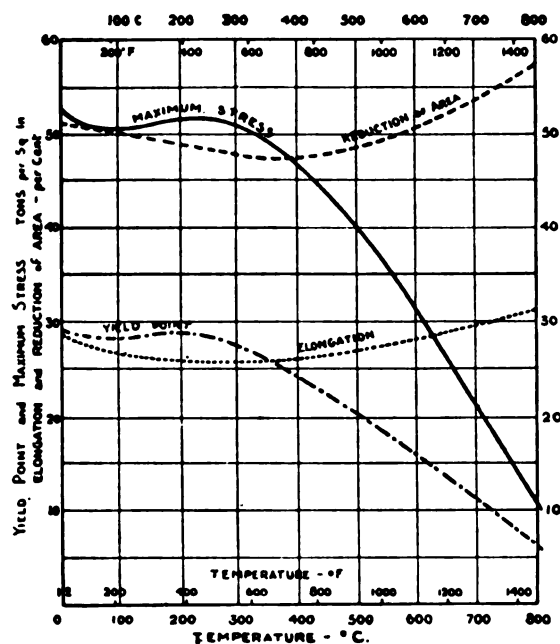


FIG. 10—Mean tensile characteristics from 0 deg. to 800 deg. C. obtained from test-pieces 13.8 mm. diameter x 100 mm. Gauge length taken from 16-mm. rolled bar in the condition as rolled.

The mechanical characteristics at high temperature, which were hitherto mentioned, result from tests made in the same condition as in the cold, with the ordinary rate of extension of the test-pieces: about 0.8 in. per minute. These results lose their significance, for any metal, when the temperature is exceeded beyond which the effects of viscosity become appreciable in its particular case. It is necessary, therefore, to have recourse to tests under constant load, in which is measured the time necessary for breaking a test-piece under a given load, at the temperature of the experiment. For high temperatures, and in practice, when 350 deg. or 400 deg. is exceeded, it is necessary to classify metals according to the results of tests at constant load. The metal is superior to steels with 13 per cent of chromium as regards its mechanical resistance under permanent load, at high temperature.

Conclusions

The majority of metals actually in use for the blading of turbines have now been reviewed, and may be summarized thus:

Brass—Metal of weak mechanical strength, unsuitable for use in superheated steam by reason of instability; indifferent behavior in the low pressure stages, through lack of resistance to erosion. Is only

used in the medium pressure stages of turbines, to the extent which its mechanical properties permit.

Nickel bronze and copper nickel—Metal a little superior to brass: use possible up to 350 deg., but with weak resistance to erosion. Its tensile strength and elastic limit permit of its use in the medium pressure stages.

Nickel copper—Very little oxidizable at current temperatures, but doubtful approaching 400 deg., at which temperature it rapidly becomes spoiled in superheated steam. Does not resist the causes of erosion. It is the most costly of all metals advocated for blading.

Steel with 5 per cent of nickel—Excellent steel for construction of blades in all stages; it resists high temperatures well, and is good against erosion when the vacua are not too extreme. Its great inconvenience is its feeble resistance to corrosion. It ought never to be used when condensation is effected by sea water, briny or impure waters.

Ferro-nickel with 25 to 36 per cent Ni—An unsuitable metal for working in steam.

Steels with about 13 per cent chromium and similar steels—These steels can properly be used in the high pressure stages if the temperatures are not too high. In the medium pressure stages their use could be recommended, but since they are not absolutely inoxidizable, it is better to refrain from doing so. In the low pressure stages their only moderate resistance to erosion makes them little to be recommended.

Homestead Valve Acquires New Plant

The influence of the development of modern transportation upon the industries is well illustrated in the announcement recently made by the Homestead Valve Manufacturing Company of Homestead, Pa. This company has been located in the busy industrial section of Homestead, Pa., since the time of its establishment, over 35 years ago. In this location, the firm developed and became generally known throughout the power plant and industrial world.

Its original product, the Homestead quarter-turn valve has been augmented by the addition of the Homalco blow-off valve, Homestead protected seat hydraulic operating valve and other standard and special valves.

When an opportunity came to purchase a modern plant located in the Narrows Run Road, Coraopolis, Pa., the company after considering the move fully, decided to purchase this plant and to move their factory and offices to the new location. This plant was erected during the war. It is situated in a narrow valley with heavily wooded hills on either side. The grounds are well landscaped with flowers surrounding the buildings and lining the sides of the drive-ways leading to the plant. An unusual setting for a manufacturing plant.

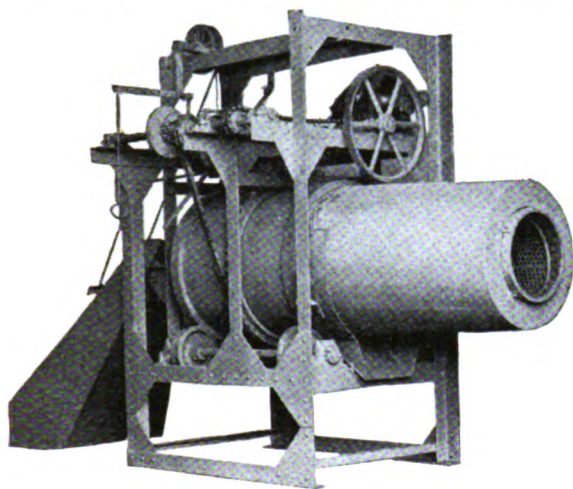
With the plant, the company also secured 108 acres a part of which is suitable for further expansion. The buildings consist of a three-story factory building of concrete construction, an office building, a separate foundry building, and a building which will be used for a pattern shop and storage purposes, with other necessary garage buildings, oil storage, etc.

WITH THE EQUIPMENT MANUFACTURERS

Star Return Tumbling Barrel

The Ideal Industrial Machinery Division, of Winton Place, Cincinnati, Ohio, has recently developed a new type of tumbling barrel, known as the Star return tumbling barrel, especially designed for cleaning drop forgings, heavy stampings, or castings.

The parts are tumbled with stars or slugs, together with flint shot, silica sand or steel shot, using a weight



of stars approximately equal to the weight of parts to be handled. In tumbling the work with this proportion of stars and sand the parts are prevented from touching each other and are floated in the stars and acquire a finish which is not to be distinguished from a sand blasted finish. Furthermore, the scale is thoroughly removed even from alloy steel forgings without denting the work and without destroying the corners or designs on the parts.

The labor involved in handling work in this barrel is almost negligible. The work is charged into the machine by means of a power loader which is shown, and tumbled in the barrel with the stars and sand. In order to discharge the work, it is merely necessary to reverse the rotation of the barrel. This automatically discharges the work at the end of the screen. The stars and sand are separated out and fall into the cone-shaped jacket, which surrounds the screen. When the barrel is again rotated in the tumbling direction, the stars automatically return to the tumbling compartment. Thus it is never necessary to handle the stars or sand, as the barrel separates these from the work automatically and returns them to the tumbling compartment automatically when the barrel is rotating in the tumbling direction.

This transfer and separation of the stars is accomplished by means of a patented cup arrangement of very simple and rigid design in the head between the tumbling compartment and the cone which surrounds the separating screen.

The barrel is mounted on four trunnion rollers, the two on each side being mounted on a common shaft which is supported in Medart Timken bearing-equipped pillow blocks. Aside from the improved

starting and running qualities thus obtained, the selection of the bearings was determined by their ability to withstand heavy, fluctuating loads. They also simplify the lubrication problem of the machine, the housings being designed to hold a large reserve supply of lubricant, and to positively exclude all dust, sand, or grit. The barrel is equipped with an exhaust hood for connection to the standard exhaust system.

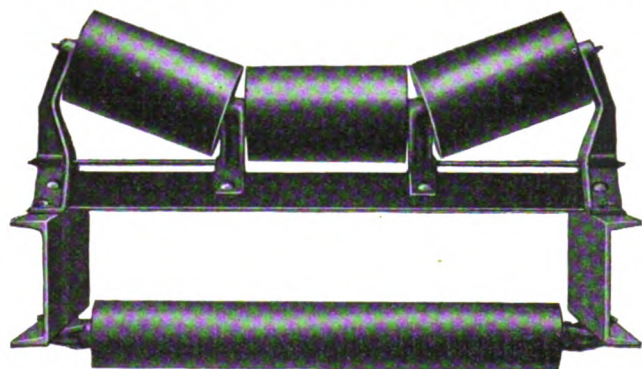
The complete line includes machines of several sizes and capacities, ranging from those having a 24 by 18 in. tumbling compartment, and a load capacity of 150 lbs., to those having a 60 by 48 in. compartment with a capacity of 4,000 lbs.

Belt Conveyor Idler

The Fairfield Engineering Company of Marion, Ohio, has placed on the market a belt conveyor idler for which it claims life time service. The design of the idler is the work of Mr. Earl D. Stearns, who recently joined the Fairfield organization as vice president. Mr. Stearns was formerly president of The Stearns Conveyor Company of Cleveland.

There are a number of features upon which the claim of life-time service for the idler is based, among which is the use of the de Lavaud cast iron pipe construction of the roller. This product is a centrifugally cast iron pipe, very dense and close grained and entirely free from blow holes and slag pockets. Due to the uniform wall thickness and trueness to shape, the de Lavaud pipe roller runs true and without vibration. They are also highly resistant to rust or abrasion.

Timken bearings are used throughout, and lubrication is of the direct, high pressure type. All grease pipes are extended to the end of the supporting frame, making the grease connections all easily accessible and eliminating the necessity of reaching under mov-



ing belts. Another feature of the lubricating system is the four pass, dust proof labyrinth grease seal, with small diameter exit in the outside washer. As there is no grease pocket outside the grease seal washers, the idler cannot throw grease.

An important service feature is the interchangeable roller. All rollers on each idler are the same face, with ends alike so that rollers can be inserted between any bracket or turned end for end between the brac-

kets. Bearing adjustment is positive, with any degree of fineness and rollers do not lose adjustment when removed from the brackets. The heavy cast iron brackets which hold the idler solidly in place, are mounted on a self-cleaning, angle base. If desired, bases are furnished tilting the idler in the direction of belt travel to insure a true running belt. The face of the return roller supports the belt $1\frac{1}{2}$ in. above the bottom flanges of the stringer channels, giving good belt clearance above supporting frame cross members. Oscillating bearings are not required or used, so return rollers can be set to properly train the belt.

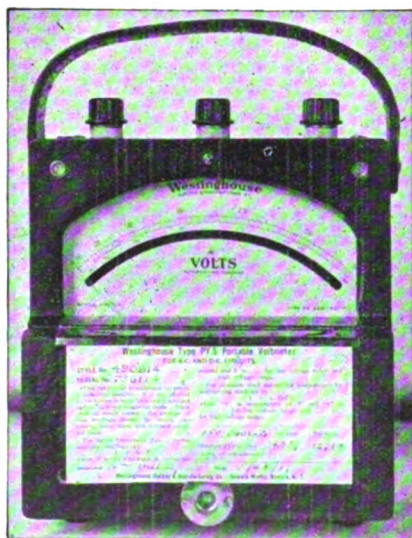
Portable Alternating Current Instruments

The Westinghouse Electric & Mfg. Company announces a new line of portable a.c. instruments designated as type PY5. They are of the direct-reading type and are applicable for general testing and laboratory work where high accuracy is required.

The voltmeters and single-phase wattmeters are of the electrodynamic type. The ammeters are of the moving iron type using vanes of non-residual metal. All instruments are shielded and are damped by an improved design of air damper making possible accurate measurements on fluctuating loads.

The ammeters have a double range which can be changed while the meter is in use by a series-parallel switch mounted in the case. The movements are mechanically strong and will successfully stand high momentary overloads. They may be used on circuits up to 500 cycles and also on d.c. with but slight reduction in accuracy.

The voltmeters have an accuracy of $\frac{1}{4}$ per cent and can be used without appreciable error on d.c. and on a.c. up to 133 cycles. They are provided with a push-button for closing the circuit. This can be locked



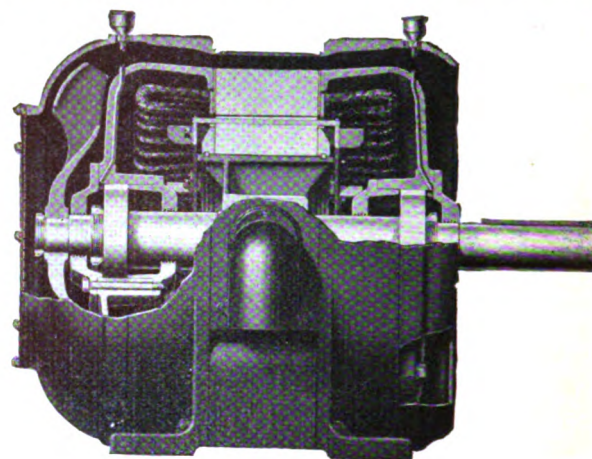
in the closed position when using the instrument for continuous service.

The single-phase wattmeters have an accuracy of $\frac{1}{4}$ per cent and may be used on circuits up to 400 cycles without requiring correction for phase displacement. The current circuits are double range with series-parallel arrangement of coils, and are controlled by a switch inside the instrument operated by a knob

in a recess in the case. Voltage ranges are changed by changing the terminal connections. The voltage circuit contains a push-button switch which may be locked in the closed position.

Totally Enclosed Fan-Cooled Motor

A new line of totally enclosed, fan-cooled motors, 1 to 50 hp., has been developed by Allis-Chalmers Manufacturing Company. In this new design, all of the active parts, such as, stator core, stator winding and the rotor, are completely enclosed, preventing contact of outside air, dirt, dust, fumes, moisture, etc.,



with the interior or active parts. Heat is carried away by a sufficient volume of cooling air forced around and across those parts which conduct the heat from the interior to the outer surfaces. A circumferential air jacket controls the path of cooling air. Solid cast iron bearing housings are attached to stator end heads with machined fit, which, with grease packed bearings, form a perfect end closure. Internal parts of motor are readily accessible by removal of housings. A unique feature is that in many ratings this totally enclosed design delivers the same horsepower output as is obtained from the same frame in the standard open rating. Temperature rise is within 55 deg. C. measured by the resistance method. The design provides for a most rugged construction with a minimum number of parts.

Great Lakes Car Dumper to Set Speed Record

Plans for a new electric car dumper, expected to set a new record for speed, have been completed by the Toledo & Ohio Central Railroad. The new dumper will be built by Heyl & Patterson and is expected to be completed in March, 1929. It will be located at Toledo adjacent to the first all-electric car dumper installed on the Great Lakes, also owned by the T. & O. C. R. R.

The new dumper will be of the lift and turnover type with a variable dumping position; i.e., the car can be raised and dumped at any height between the maximum and minimum pin positions. Complete electric equipment will be supplied by the General Electric Company. The mule haul will be driven by two 500-hp., shunt-wound, d.c. motors, and the cradle will be driven by two motors of the same type and rating. Control will be of the Ward Leonard (variable volt-

age) type, incorporating special features to meet the exacting requirements of such service. Both a.c. and d.c. motors will be used on the dumper, the total equipment involving an aggregate of approximately 3,000 hp.

Power for the operation of the dumper will be purchased from the Toledo Edison Company and will be received at 6,600 volts, 3 phase, 60 cycles. This will be transformed down to 440 volts for the operation of the a.c. motors, and will be converted—by means of two motor-generator sets—to the proper voltage values for the operation of the d.c. equipment.

The Semi-Steel Pulley

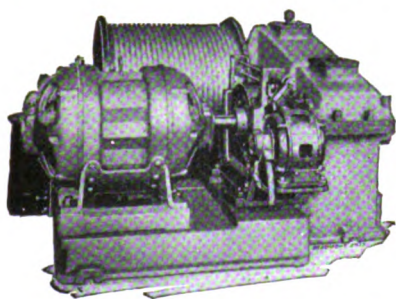
For many years the machine moulded cast pulley has been considered the last word in solid construction. It has no rivets, bolts or welds to loosen or come apart.

Now is announced for the first time the semi-steel pulley that materially improves the old type cast iron pulley, without increasing the cost. The semi-steel moulded pulley, as the name indicates, is a combination of steel and iron. The new semi-steel pulley is a stronger and finer looking pulley. It is close-grained and free from defects. Being a solid, cast unit, this new semi-steel pulley will not wear wobbly and is exceptionally well suited for a jerky load. There is practically no "wear" to semi-steel pulleys.

The W. A. Jones Foundry & Machine Company, 4429 West Roosevelt Road, Chicago, Ill., manufacturers of the semi-steel pulley, have thoroughly tested it in actual use. A new pulley catalog which describes this pulley has just been issued and will gladly be sent to anyone writing for it.

Skip Hoist Winding Machine

R. H. Beaumont Company has recently put on the market, a new improved skip hoist winding machine. This machine is "the last word" in skip winders as it



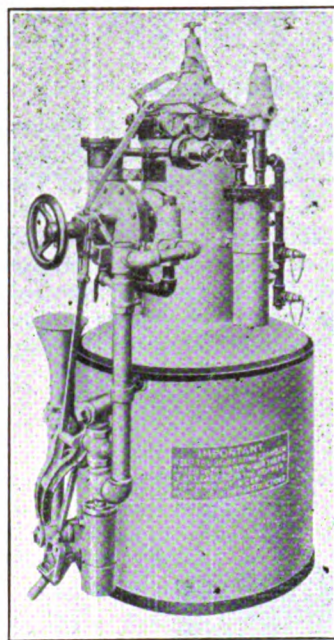
embodies many new features and the design is a reflection of 20 or more years in pioneering skip hoists for coal, coke, ashes, etc. The machine is more compact and durable. Only the highest grade roller bearings are used resulting in long life and very quiet operation.

Medium Pressure-Type Acetylene Generators

Three medium pressure-type acetylene generators for welding and cutting have been placed on the market by the Oxyweld Acetylene Company, 30 E. Forty-second Street, New York City. The type MP-2 medium

pressure acetylene generator, built in two sizes having 50 and 100-lb. carbide capacity respectively replaces the earlier medium pressure acetylene generator, while the type MP-3, having 300-lb. carbide capacity is entirely new, no pressure type generator of this size having been manufactured by this company heretofore. These three generators are suitable for supplying pressure-type or medium pressure welding and cutting blowpipes.

The type MP-2 generator is similar in construction and operation to its predecessor which has gained such an excellent reputation in the past. Several features



of the new design will improve the operation of the generator and further insure its safety. The feed mechanism has been redesigned to make the carbide shut-off even more positive than formerly. A new regulator, the type R-40, is furnished instead of the line regulator formerly used. This regulator is equipped with two gauges. One of these indicates the pressure in the generator and the other the pressure in the delivery line. The hydraulic back pressure valve, which has been simplified, and the filter are of seamless steel tubing assembled by bronze-welding and then galvanized. The

vertical pipe, leading downward to the back pressure valves and extending below the surface of the water, is fitted with an angle check valve, preventing the possibility of back pressure or flash reaching the interior of the generator. A conveniently placed clean-out door renders the feed mechanism parts accessible and easy to clean without dismantling the generator. The type MP-2 generators use $\frac{1}{4} \times \frac{1}{12}$ in. carbide. Shipping weight in the 100-lb. size is 1,100 lb. and in the 50-lb. size, 925 lb. The former has a diameter of 3 ft. 5 in. and the latter 3 ft. 1 in.

The type MP-3 medium pressure acetylene generator has been placed on the market to meet the demand for a pressure-type generator of large capacity that will supply gas with a minimum pressure fluctuation and with minimum expense for maintenance.

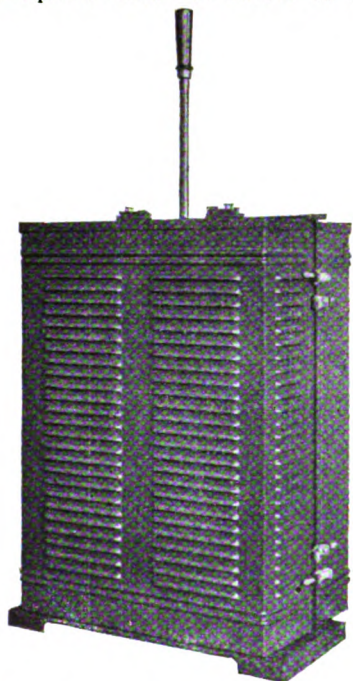
The same principle of carbide feed that has proved satisfactory in the popular Oxyweld balance seal generator is used in the type MP-3. The feed is driven by a motor actuated by a weight. A diaphragm pressure control is used in connection with the motor to regulate the feed and maintain proper pressure in the generator. Two changing doors facilitate filling the hopper. A clean-out door is provided which permits cleaning the carbide feed disc without removing the generator top. The hydraulic back pressure valve is so arranged that it is always filled with water before the generator itself is entirely filled. An overflow-level check plug has been provided in order that the operator may check the water level at any time. When

recharging is necessary, the interference, which is of simple and sturdy construction, operates the relief valves, locks the feed motor so it cannot operate, and permits the carbide doors and water filling cock to be opened. The feed motor is rendered inoperative if zero pressure exists in the generator because of a pronounced leak or any other contingency. The operating pressure can be changed by turning the adjusting nut on the feed control. During normal operation the set pressure will not vary more than about 1 lb.

This generator uses $1\frac{1}{4} \times \frac{3}{8}$ in. carbide. The overall height is slightly over 120 in. and the height to the top of the generator shell is 104 in. The diameter of the shell is $42\frac{1}{2}$ in. Shipping weight 2,300 lb.

E.C. & M. Dinkey Controller

The Electric Controller & Mfg. Company, of Cleveland, Ohio, announce the new E. C. & M. Dinkey controller, which was shown for the first time at the Iron and Steel Convention in Chicago. Ebony asbestos is used in place of slate, and the ventilated contacts are raised $9/16$ in. from the dial face. Contact supporting-lugs are attached to the front of the dial and are removable from the front. The support lug has a single square head set screw to tightly clamp



the lead wire. A welded steel frame is used. The main arm is carried on ball bearings. Smooth center top, of notch top and roller type is a feature. A bearing-spider casting supports dial as well as arm and quadrant bearings, insuring correct alignment, and even contact pressure. Nickel alloy resistors are employed, guaranteed against breakage in shipment and in service for one year.

Development of Kleenkut Shear Knives for the Steel Industry

For thirty-nine years, the Heppenstall Forge & Knife Company, has been manufacturing high grade solid steel shear knives. During the greatest part of this period, practically all the shear knives manufactured were produced from a high grade tool steel.

However, within the past 18 months, a decided change has taken place.

The advent of mechanical devices, giving increased tonnages in sheet and tin plate mills, made it absolutely necessary that shear knives be manufactured that would give greater service. This led to the development of the "Heppenstall Kleenkut" shear knife which is being produced after a great deal of research work as well as the modernizing of all the equipment necessary to produce shear knives. This shear knife is today being used in tin mills, strip mills, and all classes of sheet mills.

Nearly all tin plate manufacturers have adopted Kleenkut shear knives on their squaring shears; the service given on these knives is in all cases, eight times the amount of service that was obtained from the former ordinary carbon tool steel knife. From actual records, tin plate mills are now shearing from 30 to 37 hot mill turns on one cutting edge.

The modern tin mills today are all using mechanical doublers. Here again "Kleenkut" shear knives are used, giving record runs on this particular type of shearing.

This high grade alloy steel knife is, also, available for shearings sheets of all sizes. Sheet mills are now securing record tonnages in shearing, with the use of the "Kleenkut" shear blade.

In the shearing of strip steel which with the present method of continuous rolling, extremely difficult service is encountered; these same "Kleenkut" knives have given as much as 31 24-hr. days of continuous shearing service on one edge of a knife.

The steel shearing problem of steel plants today is one which has been solved almost completely by the largest shear knife manufacturer in this country, namely: The Heppenstall Forge & Knife Company, of Pittsburgh. The introduction of the "Kleenkut" shear knife is certainly one of the outstanding features of modern research development undertaken for the betterment of the steel industry.

Improved Single-Phase Motors

The General Electric Company announces an improved single-phase, repulsion induction motor. This motor, in sizes including $\frac{3}{4}$, 1, $1\frac{1}{2}$ and 2 hp. at 1,800 r.p.m., supplements the present General Electric line of SCR motors. It is of the constant-speed, high starting torque type for general application.

One of the most important improvements is the more efficient use of the stator punchings. The motor is enclosed except for ventilating openings in the lower portion of each end shield. Air is drawn through the ventilating openings at the pulley end by means of an internal fan, passes around the stator laminations and out through the ventilating openings in the commutator end. This construction makes a practically enclosed motor and provides complete protection against falling particles and splashing water. In spite of this, and the small size of the motor, it is designed to operate within a temperature rise of 40 deg. C. This materially broadens the field of application, permitting the use of a standard 40-deg. motor in many cases where only a larger, closed motor would otherwise be chosen. The ventilating openings in the end shields have been so designed that they will meet the requirements of the various safety bodies for protection against accidental contact.

TRADE PUBLICATIONS

Information concerning the Erie City three-drum water tube boiler and its application in industrial plants is contained in two pamphlets which can be obtained by addressing the company at Erie, Pa. Both pamphlets by many illustrations bring out the principal features incident to this boiler. A third pamphlet gives data and the outstanding features pertaining to the Erie City unitype pulverizer.

* * *

Distribution is being made by the Foster Wheeler Corporation, 165 Broadway, New York, of Bulletin 304, in which is complete data concerning the history, application, and construction of Foster superheaters. Several pages are devoted to an explanation of the use of superheated steam. Tables of steam properties are also included.

* * *

"The Most Efficient Drive in Industry," is the title on a brochure published by the Electric Machinery Mfg. Company, of Minneapolis. It is a comprehensive description of the characteristics and service rendered by synchronous motors as employed for driving machinery of many classes. While the subject matter is quite complete, it can be easily comprehended by those not thoroughly versed in electrical engineering. It will prove especially interesting to plant engineers who are concerned with the installation and maintenance of synchronous motors.

* * *

The Falk Corporation, Milwaukee, announce their new Bulletin No. 180 on Falk flexible couplings. This bulletin contains information not included in the issue it supersedes and it lists one additional size of coupling—the 20½ C. It also contains a new list of service factors which have been reduced to allow for the selection, in most cases, of smaller and hence less expensive couplings. It describes the CS type developed particularly for close coupled applications and also the CH type added to the standard line for high speed turbine work. Both these types retain the same operating principle as the standard series which has been on the market for some years and are particularly adapted for absorbing shocks and compensating for misalignment of coupled shafts.

* * *

Four publications are being distributed by The American Manganese Steel Company. "The Manganese Steel", a booklet, reviews the history of the use of manganese; it also tells what it is, what it does and what it is for. "PyraSteel—For High Temperatures," is employed, as plainly set forth in a second booklet, for the construction of carbonizing boxes, furnace conveyors, annealing trays, oil burners and other purposes requiring a heat resisting metal. The third booklet bears the title "For Hard Service Evansteel." This steel "is a nickel, chrome alloy possessing high tensile strength and toughness, and yet it is easily machined." It is recommended for making die blocks, tractor frames, truck wheel castings, excavating machinery parts, etc. A leaflet mentions new applications for Amsco manganese steel, Fahr alloy and other products. The address of the company is 333 North Michigan Avenue, Chicago, Ill.

Richards & Geier, of 274 Madison Avenue, New York City are distributing the fourth edition of "Patents—Law and Practice," by Oscar A. Geier, giving in 48 pages considerable useful information for those interested in inventions and trade marks. The book is offered for free distribution.

* * *

The Hyatt Roller Bearing Company has mailed a leaflet setting forth the advantages of roller bearings on railroad cars. It is a reprint from an advertisement which appeared in the "Saturday Evening Post."

* * *

Some information of interest to consumers of spiegeleisen will be found in a booklet bearing the name of the metal; and published by The New Jersey Zinc Company. The booklet gives some historical matter, analysis of grades, a table of equivalent values of spiegeleisen and 80 per cent ferro-manganese, and sampling and analytical methods. It is free on request.

* * *

"Industrial Lubrication," published by the Acheson Graphite Corporation, of Niagara Falls, N. Y., describes the 60 different types and consistencies of Gredag lubricants and gives definite recommendations for their application to industrial and automotive machinery of all kinds. It also contains technical and engineering data of value to all operators of machinery.

"Gredag" is the trade name applied to all of the high quality grease lubricants manufactured by the Acheson Graphite Corporation, at Niagara Falls, N. Y. These lubricants range in consistency from free-flowing fluids to stiff pastes and have the special characteristics necessary for bearings, gear, cable, chain, plunger, spring, roll neck and general lubrication. All grades of Gredag contain Acheson lubricating graphite, an electric furnace product having a guaranteed purity of 99.9 per cent. Pure graphite improves all metal surfaces, resists shocks and pressures, is unaffected by temperature changes and provides a valuable safety factor which insures uninterrupted lubrication. Copies may be had from the company.

* * *

The new Superheater Catalogue No. 304 of the Foster Wheeler Corporation, which has just been completed consists, largely, of illustrations of notable superheater installations so that the reader may immediately grasp the manner in which installations are made, together with surrounding conditions, many of which are very difficult to visualize from a drawing without great study and familiarity with the subject. The catalogue gives short statements covering the history of Foster superheaters and their application to many types of boilers, including longitudinal drum, cross drum, bent tube and return tubular. These in turn include many modifications of design such as vertical and horizontal baffling, waste heat and single pass. The types of superheaters particularly emphasized are convection, radiant heat, combination, separately fired, waste heat and portable. The catalogue is completed with a steam table extending up to 1500 lb. absolute pressure and 300 deg. superheat.

* * *

Catalog No. 80 issued by the Leeds & Northrup Company, of Philadelphia, contains 28 pages of illustrations and text concerning resistance thermometers.

TRADE NOTES

The Erie Railroad Company has bought a 300-hp. oil-electric locomotive from the Ingersoll-Rand Company, the General Electric Company and the American Locomotive Company. This is the fourth of these units purchased by the Erie Railroad Company.

* * *

At the fifty-fourth convention of the American Electrochemical Society, at Charleston, W. Va., Dr. Edward Goodrich Acheson, known the world over for his electric furnace products, yesterday presented to the society the munificent sum of \$25,000 as a trust fund. This fund is to form the basis of an award every second year of a gold medal and a prize of \$1,000 to any man who has made a distinguished contribution to any of the branches fostered by the American Electrochemical Society.

* * *

Botfield Refractories Company, Philadelphia, Pa., manufacturers of Adamant fire brick cement, Adamant-Adachrome and the Adamant gun, announces the appointment of Mr. W. E. Tierney as its representative in the south and southwest. Mr. Tierney is a mechanical engineer and a graduate of Tulane University. Mr. Tierney's headquarters will be in New Orleans.

* * *

The supervisory and executive staff of the Interstate Iron & Steel Company, of Chicago, Ill., have been provided with group life insurance exceeding \$350,000 through contract with the Metropolitan Life Insurance Company. The plan is being underwritten on a co-operative basis, the employer sharing the cost with its employees.

Each participating supervisor receives \$5,000 of life insurance, and each executive \$7,000. Included in the life contract are total and permanent disability benefits. Under the terms of this clause, an employee becoming completely disabled before age 60, will receive the full amount of his life insurance, with interest in monthly installments.

* * *

The Semet-Solvay Engineering Corporation has been awarded a contract for the erection of a complete new water-gas plant by the Stamford Gas & Electric Company. Work will be started at once and it is expected to have the plant in operation before the end of the year.

The water-gas building will be constructed to harmonize with other structures now on the company's property. Framework will be of steel and the panels will be filled in with pressed brick. Roofing will be of cement tile. The water-gas room will be approximately 48 ft. x 55 ft., 34 ft. high.

* * *

The International Combustion Engineering Corporation, of New York, recently acquired the Hedges-Walsh Weidner Company, Chattanooga, Tenn., which was formed by combination of the Casey-Hedges Company and the Walsh & Weidner Boiler Company and is now in position to supply any type of boiler, large or small, now available in the American market. With its existing line of fuel burning equipment the company can install steam generating plants of all

sizes and types, complete. The newly acquired companies will function through Combustion Engineering Corporation, the American operating subsidiary of International Combustion Engineering Corporation.

* * *

On August 15, The Brown Instrument Company, Philadelphia, started operations on extensive improvements to its heating plant, including enlargement of the building housing the boiler room and increase of boiler capacity.

Plans for building alterations include a new floor level and the supporting of the roof on steel instead of wood. Space will be provided for a complete steam plant of sufficient capacity to heat a building having floor space equal to three times that of the present building, now occupied by this company.

One H. B. Smith No. 60, 17-section boiler is now being installed. The capacity of this boiler exceeds that of the three boilers previously used. Two of the old boilers have been removed and the third is being reset to bring the water level at the same point as that of the new boiler.

The installation hitherto employed was oil-fired and this system will be continued with the new equipment. The management has found oil burning more economical than coal for the conditions of their business and a 6,000-gal. oil tank is accordingly being installed beneath the boiler room floor. The tank measures 7 ft. in diameter by 20 ft. in length.

This same tank will be equipped with a Brown recording liquid level gage which will show at all times the amount of fuel in the tank and the rate of consumption.

Other Brown instruments will be installed including a resistance thermometer. By means of the latter instrument the operating engineer will, by simply turning a switch, be able to tell the exact temperature prevailing in each department of the entire plant without leaving the boiler room. Among boiler operating accessories will be provided a double vacuum pump unit. This unit is practically two pumps on one base, providing a reserve pump for use in emergencies.

All contracts and orders for material have been placed covering the entire job and the work is 30 per cent completed as of August 28.

* * *

The Bethlehem Steel Company, has awarded a contract, amounting to several hundred thousand dollars for the furnishing of the most modern W-S-M automatic ore unloader for their Lackawanna plant at Buffalo, to The Wellman-Seaver-Morgan Company, Cleveland, Ohio, for delivery and erection ready for operation by the opening of navigation next spring.

This unloader will be placed alongside and operate on the same tracks as the five other machines of this same type, and will have a non-telescopic bucket of 17 tons capacity, a receiving hopper, with revolving disc discharge, with apron feeder mounted on a rotating frame and a belt conveyor with a traveling tripper.

Ore will either be loaded into railroad cars standing on the first track inside the front leg, or stocked under the cantilever beyond the rear leg through the receiving hopper, apron feeder and belt conveyor with tripper. The trolley with bucket will be designed for one trip in 50 seconds with 17 tons of ore.

The machine is electrically operated throughout, there being a total of 10 electric motors required ranging in size from 15 to 275 hp., the total horsepower of all motors being over 900.

NEWS OF THE PLANTS

The Otis Steel Company, of Cleveland, Ohio, has announced that work will start immediately on the erection of the second of its three open-hearth steel ingot furnaces which constitute an expansion program now under way. The new addition will be completed at an early date, and will give the Otis Company seven open-hearth furnaces with an annual capacity of 600,000 tons. The first of the three furnaces of the expansion plan was put into operation in May.

* * *

The Sharpsville Furnace Company, with plant at Sharpsville, Pa., and which recently acquired the blast furnace of the American Steel & Wire Company, at Neville Island, Pa., has changed its name to the Davison Coke & Iron Company, with general offices in the Oliver Building, Pittsburgh.

* * *

The Tennessee Coal, Iron & Railroad Company has under construction a plant at Fairfield, Ala., where it will manufacture cotton ties. The plant will be easily ready to begin operations before the next season for the product arrives. Heretofore a small mill was installed in the Bessemer, Ala., rolling mills.

* * *

The Davison Coke & Iron Company, formerly the Sharpsville Furnace Company, blew in its Sharpsville blast furnace October 1. This stack had been down since June 4.

* * *

The Republic Iron & Steel Company relighted a stack at its Haselton blast furnace group early in October to take the place of the stack at Warren, Ohio, which went out for relining about that time.

* * *

Mackintosh-Hemphill Company, Pittsburgh, engaged in the design and construction of rolling mill equipment has recently been reorganized under new management. The following officers have been elected: Chairman of the board, H. V. Blaxtor; vice president, F. H. Moyer; treasurer, W. C. Rice, secretary and assistant treasurer, D. H. Baum. Board of directors: H. V. Blaxtor, John W. Chalfant, Edwin Hodge, Jr., Herbert A. May, J. H. O'Neill, W. C. Rice and T. C. Ward.

Mackintosh-Hemphill Company was founded in 1803. The company in later years took over the A. Garrison Foundry Company, Pittsburgh Iron & Steel Foundries Company and the Woodard Machine Company.

Public Use Necessitates Increase in Long Distance Telephone Construction

An additional expenditure of \$11,042,000 for constructing new long distance telephone facilities during 1928 has been authorized by the American Telephone and Telegraph Company, according to an announcement by T. G. Miller, general manager of the long lines department of that company. This increase, made necessary by the unusually rapid growth in the number of long distance calls during the first half of

this year, brings the total appropriations for new construction during 1928 on the longer haul telephone circuits of the Bell System to \$49,038,000, as compared with \$36,406,000 expended during 1927, the previous record year in construction.

This expenditure will be applied to extensions and improvements on long distance lines in all sections of the country, including the three transcontinental routes. During the first half of 1928, as compared with the same period of 1927, telephone users increased their use of the long distance circuits of the American Telephone and Telegraph Company an average of 20 per cent. Nor did they forget to call abroad frequently with the result that part of this increased expenditure will be used to speed up the preparation of short wave transoceanic systems, to supplement the long wave transatlantic telephone system in service since January, 1927.

Other construction items sharing in this additional appropriation are aerial wire lines, telephone cable lines, carrier current telephone and telegraph circuits, whereby several messages can be sent simultaneously over one pair of wires; telephone repeaters and loading coils, which amplify the weakening voice currents on long haul routes; radio program transmission circuits.

COMING MEETINGS

Oct. 11-13—American Gear Manufacturers' Association. Semi-annual meeting, Statler Hotel, Buffalo. T. W. Owen, secretary, 3608 Euclid Avenue, Cleveland.

* * *

Oct. 17-19—Society of Industrial Engineers, fifteenth national convention, Rochester, N. Y. George C. Dent, secretary, 205 West Wacker Drive, Chicago.

* * *

Oct. 19-20—American Engineering Council, meeting of the administrative board at Pittsburgh, auspices of the Engineers Society of Western Pennsylvania. President, Arthur W. Berresford, 29 W. Thirty-ninth Street, New York City.

* * *

Oct. 24—American Refractories Institute, Fall meeting, Vanderbilt Hotel, New York City. Miss Dorothy A. Texter, secretary, 2202 Oliver Building, Pittsburgh, Pa.

* * *

Oct. 26—American Iron and Steel Institute, Fall meeting, Commodore Hotel, New York City. E. A. S. Clarke, secretary, 75 West Street, New York City.

* * *

Nov. 13-17—American Institute of Steel Construction, Inc., sixth annual convention at Biloxi, Miss. Charles F. Abbott, executive director, 285 Madison Avenue, New York City.



J. S. Irvin formerly special representative for Trumbull Steel Company, of Warren, Ohio, has been made general manager of the new tin-plate plant of the Columbia Steel Corporation now under construction at Pittsburg, Calif. Mr. Irvin was at one time manager of the Laughlin Works, American Sheet & Tin Plate Company, Martins Ferry, Ohio.

William H. Cloverdale, who has been associated since 1913 with the Gulf States Steel Company, Birmingham as consulting engineer and a director, has been elected president of the company to succeed the late James Bowron. John W. Platten, chairman of the finance committee was named as chairman of the board, and Lester E. Geohegan, vice president and general manager has been made a director. Mr. Cloverdale is a member of the firm of Cloverdale and Colpitts, consulting engineers at 52 Wall Street, New York City.

L. Gerald Firth, general manager, Firth-Sterling Steel Company, McKeesport, Pa., left on a European trip, a month of which will be spent at the Sheffield works of the associated company, Thomas Firth & Sons Ltd.

Frank Becker has been made superintendent of the Perry Iron Company, with a blast furnace at Erie, Pa. Mr. Becker for several years has been general superintendent of the Punxsutawney Furnace Company, Punxsutawney, Pa.

Frank W. Cramer has been appointed chief engineer of the Republic Iron & Steel Company, Youngstown, Ohio. Formerly Mr. Cramer was assistant superintendent of the Cambria plant of the Bethlehem Steel Corporation, at Johnstown, Pa. Mr. Cramer was at one time associated with the American Gas & Electric Company, at Scranton, Pa.

C. C. Henderson has been elected treasurer of the Allegheny Steel Company, succeeding R. D. Campbell, recently resigned. F. H. Stephens was made assistant treasurer in place of Mr. Henderson.

Benedict Crowell, Cleveland, assistant secretary of war and director of munitions during the World War, has been re-elected president of the Army Ordnance Association.

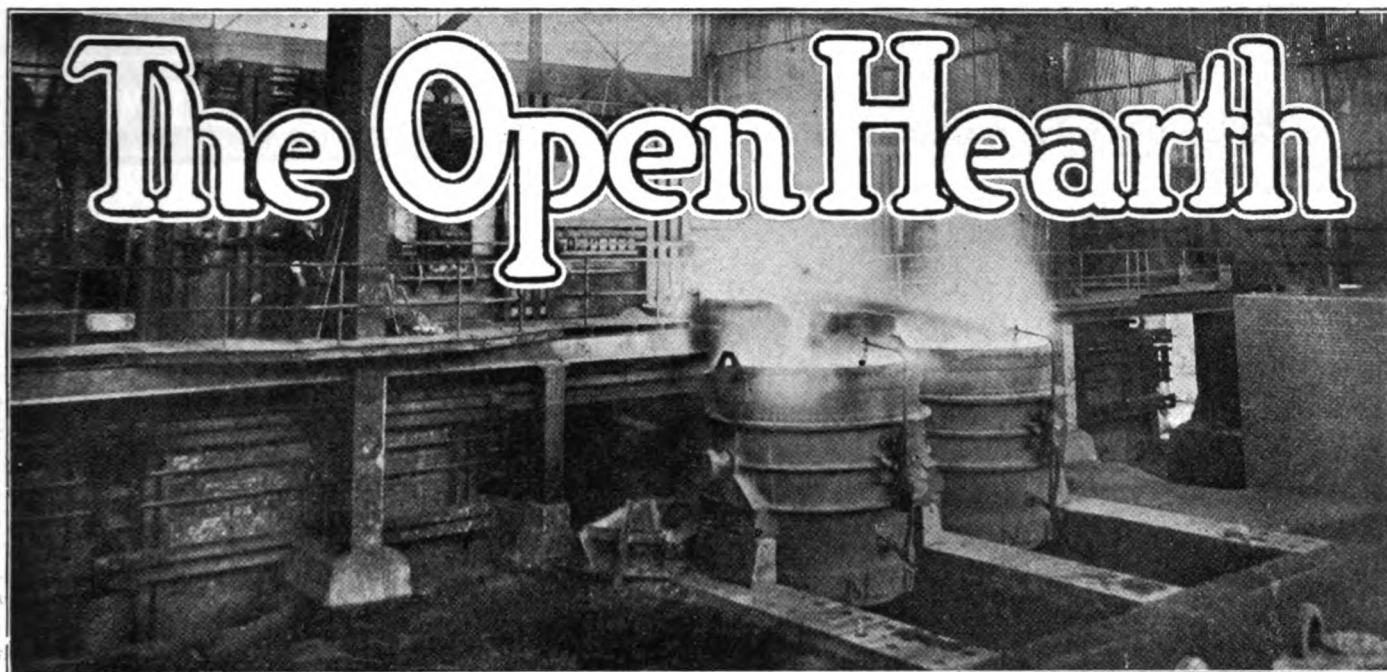
C. L. Taylor has resigned his position as chief engineer of the Morgan Engineering Company, Alliance, Ohio, to become vice president and head of the engineering department of the Aetna Standard Engineering Company, of Youngstown, Ohio. Mr. Taylor was with the Morgan Company for 18 years.

Harry F. Raab has been made assistant superintendent of the electrical department of the Cambria plant of the Bethlehem Steel Corporation, succeeding Frank W. Cramer, who resigned recently to become affiliated with the Republic Iron & Steel Company, Youngstown, where he will take charge of all electrical construction work for the various plants of the company. Mr. Raab has been an employee of the Cambria plant for the past 15 years.

Benjamin F. Faunce has resigned as superintendent of the car department of the Cambria plant of the Bethlehem Steel Corporation and will be succeeded by Lindsay C. Pritner, who has been in the employ of the company for the past 37 years. Mr. Faunce will devote his time to the Brown-Fayro Company, manufacturer of machine boilers, coal and ore tipples, chutes, mine pumps, etc., at the Sheridan plant. Mr. Faunce organized the Fayro Machine & Engineering Company, Johnstown, Pa., in 1921, and is president of the company.

George E. Learnard, president of the International Combustion Engineering Corporation, has sailed on a business trip to France, Germany and other countries in Europe.

Frank B. Parker, general manager of Briggs & Turivas, Inc., with general offices at Blue Island, Ill.—a Chicago suburb—and dealers in scrap iron and steel and iron and steel products, has been made vice president and general manager.



Wallace G. Imhoff, formerly metallurgist of the electrical materials department of Hubbard & Company, Pittsburgh, Pa., has opened an office at 401 Highland Building, Pittsburgh, Pa., as a consulting metallurgical engineer in pickling and galvanizing. Mr. Imhoff's practical experience in the galvanizing field dates back over a period of 15 years to when he started in the galvanizing department of The American Steel & Wire Company, at Rankin, Pa.

Mr. Imhoff is considered an authority on the process of hot galvanizing. He has written many technical articles on the practical phases of iron and steel, and has recently covered in detail, the field of pickling. For the past year Mr. Imhoff has been the metallurgist of Hubbard & Company, Pittsburgh, Pa., in the electrical materials department, the product being galvanized pole line hardware for the power industry.

* * *

Mr. E. J. Phillips who has been selling Van Dorn products in Detroit, has gone to San Francisco to take over that territory for the Van Dorn Electric Tool Company, Cleveland, Ohio. His place in Michigan will be filled by his brother, George Phillips. Mr. J. F. Spaulding has been transferred to the Baltimore territory to fill the vacancy resulting from the transfer of Jack Beggs from Baltimore to the headquarters office in Cleveland.

* * *

Joseph A. Bohn, plant manager of the Ames Iron Works, Oswego, N. Y., has been appointed general manager, succeeding Joseph C. Gaskill, whose death occurred recently. Mr. Bohn began his career with the Ames Company as a cost accountant, then was made production manager, and following several other appointments became plant manager.

* * *

Mr. A. T. Kathner, Duralloy Company, Pittsburgh, sailed September 28 on the Isle de France to introduce the Kathner furnace in England, France, Germany and Italy. Mr. Kathner will remain abroad for three months. He is building a furnace at Forges de Geugunon, Geugunon, France, the shafts for which were made and shipped by the Duralloy Company.

Herbert P. Howell, a banker of national prominence, having been for 10 years vice-president of the National Bank of Commerce, in New York, has been selected as the senior executive of the new Commercial National Bank & Trust Company.

Before coming to New York, Mr. Howell was for many years with the Carnegie Steel Company, in Pittsburgh and in 1901 he became head of its credit department.

* * *

Mr. J. E. Sullivan, former superintendent of blast furnace and ore docks of the Sparrows Point Plant of the Bethlehem Steel Company, has been made vice president of Edgar E. Brosius, Incorporated, Pittsburgh, Pa.

* * *

F. H. Moyer was elected president of the Mackintosh-Hemphill Company at a meeting of the board of directors held October 1.

American Iron and Steel Institute

The thirty-fourth general meeting of the American Iron and Steel Institute will be held in the Hotel Commodore, New York, on Friday, October 26, 1928. There will be three sessions: a forenoon session, beginning at 10 A. M.; an afternoon session at 2 P. M.; and a banquet in the evening at 7 P. M.

The program of papers is as follows: "An Acoustic Laboratory for the Testing of Music and Other Steel Wires," W. B. White, acoustic engineer, American Steel & Wire Company, Chicago, Ill.; "Uniformity, Continuity and Magnetic Testing," A. V. DeForest, research engineer, American Chain Company, Bridgeport, Conn.; "Steel Requirements of the Aircraft Industry," H. J. French, senior metallurgist, Bureau of Standards, Washington, D. C.; "Recent Observations of Some European Iron and Steel Conditions," C. A. Meissner, United States Steel Corporation, New York; "The Present Status of Structural Steel Welding," F. T. Llewellyn, president, American Welding Society, New York; "Steels Used by the Automotive Industry," W. J. MacKenzie, vice president, Interstate Iron & Steel Company, Chicago, Ill.



THE STEEL PLANT ROLL TURNER AND DESIGNER

Floyd A. Day



Mr. Floyd A. Day is superintendent of the roll shop at the Gautier Works of the Bethlehem Steel Corporation at Johnstown, Pa. He has completed 19 years of service in roll turning and roll designing.

Progress in Steel Mill Roll Design

Historians have paid little attention to the roll designer and his work. The designer has been slowly developed through a process of evolution. Beginning in the days when he had no personality of his own, when the roller, the machinist, the draftsman, the engineer or the mill superintendent might for the time being lay aside his usual vocation and block out a set of passes for the mill rolls and have these turned up from sketches or crude templets in a corner of the machine shop, he had gradually progressed. And as the iron master's business increased from sheet iron, round and square and flat bars to rails and other shapes, this corner of the machine shop became a separate department. Eventually the boss roll turner had an office and, perhaps, a shop for his own use, where he filed out his templets and was in direct charge of all the operations, from the necking of the castings to the finished rolls. If he had a little capital he sometimes had a small shop of his own. In any case his office and shop was carefully guarded. The "No Admittance" sign was very conspicuous.

The templets, which were, as a rule, the only record of the designs, were handed out one by one to the lathe hand, so that he seldom saw the whole set together. In fact, a large part of the work was done

without templets, calipers and a few dimensions given out by the boss being all that the roll turner had to work with on certain sections.

The designs, if such they were, and the templets were considered a family inheritance and were handed down from father to son as a legacy of great value. That this was the case was largely due to the fact that practically all of the pioneer roll designer's knowledge of his art had been acquired in the hard school of experience.

This was the roll designer of 20 or 30 years ago. But modern facilities, systems of acquiring knowledge, convenience of travel and the broadening tendency regarding interchange of ideas and experiences have wrought a big change. And, as the art is still one not of theory but of experience, reliable text books on the subject are conspicuous by their absence.

But the designer of today has at his command valuable data from the records of the last quarter of a century. He is also familiar with what his contemporaries are doing. The record of his own designs are complete; the tonnages made on rolls are accurately recorded; trade journals supply him with general plans and description of the new mills and improvements to the older ones.

He has a well-lighted office and shop equipped with electrically driven lathes for turning the heaviest and lightest rolls; roll and tool grinders; surfacing, planing and milling tools; overhead cranes; skilled tool and templet makers; high speed tool steels; complete drawings and accurate templets for the shop men, and everything that contributes to the higher efficiency. It is a great stride from the little dark corner of the old time machine shop of a generation ago to the present well-equipped establishment.

But "to whom much is given, of him shall be much required." The roll designer has become the censor of all things rollable. He is required to meet the present day demands for accurate and perfect sections. He must be prepared to design successfully and roll intricate shapes without injury to the material. The demand for large tonnages requires the greatest reduction during the rolling period, and at the same time he must exercise care that with these heavy drafts no unequal strains occur in the metal.

He must have courage to do that which has never been done before, and the skill to do it well. While he has progressed considerably from the old-time methods, he has much yet to master before his art can be dignified with the name of a science.

—Extract from The Carpenter Steel News.

Weight of Plates

A steel plate 1 in. thick weighs close to 40.8 lb. per square foot. Rollers and weighers "think" in terms of a plate 1 ft. square and 1 in. thick. One-half inch plate, therefore, weighs 20.4 lb.; $\frac{1}{4}$ in., 10.2 lb.; and $\frac{3}{16}$ in., 7.66 lb. per square foot.



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A.R.I. Meeting Announced

The fall meeting of the American Refractory Institute will be held on October 24, 1928, at the Vanderbilt Hotel, New York City. The meeting will be largely devoted to the discussion of specifications. This discussion will be a continuation of the symposium on specifications that was held during the meeting at White Sulphur Springs, last May.

Start on New Babcock & Wilcox Plant

Additional details have been lately announced regarding the proposed refractories plant that is to be established at Augusta, Ga., by the Babcock & Wilcox Company, New York City, an official of the company stating that the firm is now organizing another concern to operate the plant which will be known as the Babcock & Wilcox Refractories Corporation. The company has acquired a tract of about 16 acres at Augusta for the plant on the Georgia & Florida Railroad, and expects to invest approximately \$1,000,000 in developing the new enterprise, this including the construction and equipment. Grading work has already started on the site, and the company expects to rush the work as rapidly as possible in order that the first unit may be in operation before the end of this year, or at least early next year. Clay will be obtained for use in the plant from the Albion Kaolin Company, Hephzibah, Ga.

J. H. Bell Visits Home Land

J. H. Bell, vice president sales manager of the Louisville (Ky.) Fire Brick Works, recently returned after a two months' vacation spent in England. Mr. Bell came to America from England as a boy and had never had a previous opportunity to return home.

Ironton Fire Brick Announces Nojoint Plastic Refractory

The Ironton (Ohio) Fire Brick Company has published a bulletin announcing and describing its Nojoint plastic refractory for monolithic linings and quick furnace repairs. This bulletin gives some of the technical data in which the plant engineer is interested, and makes a statement that a 24-hour delivery can be made to any point east of the Mississippi River.

Thermal Expansion Fireclay Brick

The University of Illinois Bulletin Vol. XXVI, No. 1 of September 4 has for its subject "The Thermal Expansion of Fireclay Bricks," author Albert E. R. Westman, research associate in ceramic engineering. The bulletin is the report of an investigation of the thermal expansion and correlated properties of 20 brands of fireclay bricks. Data of this nature has an unusual interest both to users of brick and in the development of ceramic theory.

Brick samples were furnished by Ashland Fire Brick Company of Chicago, Retort and Fire Brick Company, Crescent Refractories Company, Evens and Howard Fire Brick Company, J. H. Gautier and Company, A. P. Green Firebrick Company, Harbison & Walker Refractories Company, Laclede Christy Clay Products Company, Parker-Russell Mining and Manufacturing Company, Louisville Fire Brick Works, Seaboard Refractories Company, The Babcock & Wilcox Company, The Vitrefax Company, and the Walsh Fire Clay Products Company. The bulletin contains 30 pages, price 20 cents.



Charles Tredennick is superintendent of masons at the Cambria Works, Johnstown, Pa., of the Bethlehem Steel Company. Mr. Tredennick has been at the Cambria Works for 27 years.

New Harbison-Walker Plant Working

Harbison-Walker Refractories Company, Pittsburgh, Pa., is getting ready to install dry pans and a hydraulic press at the plant at Hays Station, Pittsburgh. This machinery will be used to manufacture diaspore brick.

The new tunnel kiln units built by this company at Clearfield and Templeton, Pa., and at East Chicago, Ind., are now in operation and brick of high quality is being manufactured. The kiln at East Chicago is burning silica brick at approximately 2,700 deg. F. This is the first attempt to burn silica brick in a tunnel kiln in this country.

Temperature-Property Characteristics

By J. F. Hyslop, B.Sc., A.R.T.C.

When a refractory is chosen for high temperature service, the first obvious information required is the temperature at which the material begins to deform, or soften, rapidly, and for this purpose the well-known Seger cones are used. As a result it is possible to say that a material has a refractoriness designated by a certain cone number. This arbitrary number indicates the temperature at which the material loses its form



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rapidly when tested under standard conditions. But it is found that this cone number, although important, does not usually indicate how the material will perform under service conditions. A much more informative test is to find the deformation characteristics of the refractory when it is subjected to known loads. In this connection A. J. Dale* has published valuable data on the under-load refractoriness of silica and clay materials.

If silica material is considered, it would be expected that the under-load refractoriness would depend largely on the constitution of the material; and Dale has shown this to be so. Generally, increased conversion of the silica to cristobalite results in an increase of strength at high temperatures. Under low load conditions, a brick which contains appreciable amounts of quartz, some cristobalite, and little or no tridymite, shows an accelerated expansion about 1,250 deg. C., and this may persist up towards 1,700 deg. C. A similar brick under high loading would be liable to fail more or less suddenly about 1,500 deg. C. On the other hand, a brick which has been well fired and shows practically complete conversion to tridymite and cristobalite, deforms under load at high temperatures in a manner which suggests that the deformation is controlled by the viscosity of the intercrystalline glassy content. It has been found that an all-cristobalite brick can withstand, under test conditions, a load of 50 lb. per square inch up to 1,700 deg. C.

The behavior of fireclay materials under load is rather more complex than that of normal silica materials, for there are inherent difficulties in interpretation and correlation of results due chiefly to presence of grog in these bodies. If firebrick is tested under load it may fail owing to mechanical breakdown of the material due to temperature effect on cohesion of the grog and matrix, or it may fail by complete subsidence on account of effect of temperature on viscosity of the matrix.

With clay materials there is generally a variable and extended range of temperature between the beginning of subsidence and the point of complete failure, and the temperature at which deformation under load begins seems to be independent of the grog content. Under high loading, firebricks show a decrease in expansion under 1,300 deg. C., and the tests carried out by Dale show that for the majority of firebricks 1,200 deg. C. can be considered a critical temperature. In all stress-temperature tests due care must be exercised in the correct interpretation of results, for a consideration of the mechanism involved in the behavior of refractories when stressed at high temperatures brings in factors such as plasticity, viscosity, and cohesion.

Corrosion

The life of a refractory in service is frequently controlled to a large extent by its ability to withstand the corrosive and erosive actions of liquids and dust-laden gases. Thus the chemical nature of the material must be carefully considered in relation to the corrosive agencies peculiar to any given process. For ex-

ample, siliceous material would be used in contact with siliceous liquids as in the acid open-hearth steel furnace, and lime, dolomite, or magnesite would be employed with liquids rich in bases, as illustrated by the use of dolomite and magnesite in the basic open-hearth steel furnace. All cases, however, are not so simple as these, and complex physico-chemical equilibria are frequently involved.

Thermal

The thermal properties of refractories, especially those at high temperatures, are difficult to estimate but accurate, trustworthy data are essential if the efficiencies of modern high temperature plants are to be seriously considered.

The principal data required in practice are the specific heat, heat capacity, conductivity, and temperature diffusivity, and the importance of any single characteristic will depend on the nature of the service the material is called upon to perform. In some cases high conductivity is required, while in others a low value may be desired, in each case the conservation of fuel being the objective. Other cases arise in which the heat capacity or the temperature diffusivity of the material may be the most important property. An excellent review of the thermal properties of refractories is due to A. T. Green.†

The specific heats of clay and silica materials are very similar even at high temperatures. The specific heat increases rapidly with temperature, and there may be as much as a 40 percent increase from 200 deg. C. to 1,000 deg. C. This factor is basic in calculating heat balances for furnaces; its evaluation, although difficult, has always been a matter of importance.

The heat capacity per unit volume of a refractory is a useful factor to have for comparative purposes. For normal substances it is the product of the specific gravity and the specific heat, but since refractories are generally porous, it is consequently the product of the apparent specific gravity and the specific heat. The apparent specific gravity of silica and clay materials at high temperatures decreases, often as much as 4 per cent, but since the specific heat increases greatly with temperature rise, say 40 per cent, it is evident that temperature has a very appreciable effect on the heat capacity. The following table after A. T. Green illustrates this point:

Heat Capacity
(Calories per c.c.)

Temp. °C.	Firebrick	Silica	Magnesite	Zirconia
100	0.400	0.349	0.621	0.470
1000	0.570	0.495	0.842	0.852

The thermal conductivity of refractories is of considerable consequence, since the value of this factor can determine to a large extent the thermal efficiency of a given plant, and it can also play a large part in controlling the life of the material under certain high temperature conditions. For clay and silica refrac-

*A. J. Dale, "Trans. Cer. Soc.," vols. 23 and 24.

†A. T. Green, "Trans. Cer. Soc.," 25, 4, 361.



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tories the conductivity increases with temperature, and for these two materials the values are of the same order of magnitude. At low temperatures, under 1,000 deg. C., the value for silica tends to be lower than that for clay, but at temperatures over 1,000 deg. C. the conductivity of the silica material is greater than that of clay. The conductivity of silica products varies according to the heat treatment, and, therefore, according to the constitution of the material. From theoretical considerations it would be expected that the thermal conductivity of bodies such as refractories would depend to a large extent on the nature and number of the component phases, and this is found to obtain more or less in practice. For example, a brick composed chiefly of α -quartz shows very low thermal conductivity, and a cristobalite brick is superior in this respect to a tridymite one. Continued heat treatment of fireclay slightly reduces the true specific gravity, and the thermal conductivity, as in the case of silica, is enhanced.

In addition to the constitution of the material, the porosity factor must be taken into account in a consideration of the conductivity. At low and moderate temperatures pore spaces act as insulators, and a highly porous brick has very low conductivity and is a good insulator up to 800 deg. C. At high temperatures, however, the pores may contribute substantially to the heat-flow through the material, and data presented by A. T. Green indicate that at elevated temperatures the quantity of heat transmitted via the pores by means of radiation and convection by the solid material. Commercial insulating material, which is of great practical value in assisting to lessen furnace heat losses, owes its characteristic property of low thermal conductivity to the amount and nature of the pores in the material. In the case of diatomaceous earth materials the pores are generally very minute and evenly distributed, and such products have low apparent specific gravity, ranging from 0.35 to 0.75.

For some purposes it is convenient to know the temperature diffusivity of a refractory, that is, the rate at which the material transmits temperature changes. This value is important in plants in which temperature is of more import than total heat, for example in coke oven, gas retort, and certain metallurgical furnaces. The coefficient of temperature diffusivity is derived from Fourier's diffusion equation, which states that the coefficient of thermal conductivity is equal to the product of the coefficient of temperature diffusivity and the heat capacity. A. T. Green has shown that the temperature diffusivity depends on the constitution of silica and clay materials. A badly burnt silica brick has very low temperature diffusivity value, and at high temperatures cristobalite material is superior to tridymitic, but at lower temperatures the order is reversed for the latter two types of material. Likewise, as might be expected, a well-burnt clay body gives a higher value than a badly burnt product.

In many industrial operations the chief thermal characteristic of a refractory is ability to resist severe temperature changes or steep temperature gradients. Severe temperature gradients can exist in refractories

more or less permanently owing to the low thermal conductivity of these materials. In their resistance to sudden temperature fluctuations, silica materials are notoriously weak. The reason is evident when their constitution is considered. All possible constituents of a silica refractory show breaks in temperature-property curves, and since sudden discontinuities occur in expansion at either low or moderate temperatures, it is clear that forces exerted by these volume changes, if they occur rapidly, may disintegrate the material. At low temperatures, cristobalite and tridymitic materials behave badly; the former is the more sensitive to sudden variations in temperature. With refractories high in α -quartz, care has always to be taken in heating and cooling through the region 500-600 deg. C.

Clay products withstand temperature variations much better than silica ones. It is generally held that coarse-textured, porous material is superior to fine-textured—but irrespective of the texture of the material, it will usually be found that the dominant feature is the amount of free silica. If this is kept low, in other words if an aluminous clay is used, the tendency to fail under severe temperature changes is much reduced. In considering this particular problem there are three fundamental factors: these are temperature diffusivity, temperature-volume characteristics, and elasticity. Since all refractories contain a glassy phase, the last-named factor is complex and involves consideration of elastic-viscous and viscous properties. The problem, therefore, is theoretically difficult to express quantitatively.

From another aspect the glassy phase is important, for it may cause mechanical weakness by precipitating cristobalite or tridymite. This would occur if a portion of the refractory happened to be kept for a long period in the devitrification range of the glass. Stresses caused by the transformation of cristobalite to tridymite may also be set up in a definite zone if the refractory is subjected to permanent temperature gradient.

These considerations all illustrate the bearing of constitution of material on resistance to thermal shock and temperature gradients; they show, too, the importance of avoiding where possible, material with dangerous volume change points.

TABLE I

	Silica	Clay
Refractoriness	1720° C.	1650° C.
Refractoriness under load (50 lb. per sq. in.)	1670° C.	1350° C.
Porosity	25-30	18-30
True specific gravity	2.65-2.30	2.63-2.50
Apparent specific gravity	1.95-1.60	1.80-2.20
Coefficient of temperature diffusivity	600° C. 0.0031 1200° C. 0.0040	0.0026 0.0033
Coefficient of thermal conductivity	600° C. 0.00140 1200° C. 0.00220	0.00145 0.00210
Specific heat	600° C. 0.279 1200° C. 0.324	0.278 0.323
Heat capacity (calories per c.c.)	100° C. 0.349 1000° C. 0.495	0.400 0.570

—World Power.

THE STEEL PLANT BRICK MASON

Missouri Products at State Fair

This year The School of Mines and Metallurgy of The University of Missouri was represented at the Missouri State Fair at Sedalia, Mo., by the Ceramic Department. The diversity of ceramic products produced in Missouri was well illustrated in this exhibit, which included refractories, sewer pipe and drain tile, face brick, pottery and enamel products as well as many of the raw clays mined in the state.

The exhibit was prepared with the co-operation of the manufacturing and mining companies of the state. The companies who co-operated by contributing to the exhibit were A. P. Green Fire Brick Company, W. S. Dickey Company, Wellsville Fire Brick Company, Missouri Clay Mining Company, Evans and Howard Fire Brick Company, St. Louis Pottery and Manufacturing Company, Hydraulic-Press Brick Company, Farber Fire Brick Company, Parker Russell Mining and Manufacturing Company, Evans Brothers Pottery, Chicago Vitreous Enamel Product Company, Mound City Roofing Tile Company, and Laclede-Christy Company.

After the fair the entire exhibit was packed and shipped to Rolla where it will be included in the permanent Ceramic Department exhibit.

According to Dr. M. E. Holmes, head of the Ceramic Department of The School of Mines, the exhibit was representative of Missouri's wealth of ceramic raw materials and products which makes it one of the leading clay centers of the world. The state ranks second in the Union in the production of raw clays, and seventh in the production of ceramic products. Prof. C. M. Dodd of the Ceramic Department was in charge of the exhibit at Sedalia.

—Brick and Clay Record.

Unit Handling—A Suggestion

Along with a study of mechanical elevating and conveying equipment to reduce the cost and the burden of handling brick, tile and other clay products, we may well give a goodly share of attention to the thing known as unit handling, that is, of making up certain size piles or quantities and handling these as a unit instead of handling each piece separately.

We have some unit handling in the clayworking industry, that is, we have some in producing and kiln setting, but the doings in other lines suggest possibilities of more of this unit handling thing in the clayworking industry. They are doing things of this kind in other lines. The lumber and woodworking industry, for example, pile rough lumber from the yards directly on trucks that can be moved from the yard into the kilns without repiling. In woodworking plants stock is piled on boats or platforms in quantities and the whole pile is moved as a unit with a lift truck. In short, there is steady and insistent progress in unit pile handling instead of individual handling of pieces.

We have some of the same thing in cement. Cement is piled on lift truck boats and platforms and handled in quantity units. Also one day a dealer con-

ceived the idea of cutting off a section of board about 2 ft. long, just long enough to lay a cement bag on it flat, and putting a cross strip under it near each end and piling enough bags of cement to make a barrel on each section of board of this kind, so that an ordinary bag truck could be nosed under it and the whole thing moved as a unit not only into the warehouse but also from the warehouse into the trucks for delivery. So it goes all around us, there is an insistent trend toward making up quantity units and devising ways and means to handle these units as a whole instead of handling each piece individually. Surely there is a chance to do some of this in the clayworking industry, to develop crates, boxes, platforms and a number of different ideas for handling the products as a unit, not only in the yard and from the yard to the cars, but also for handling at the delivery end from cars to the job. Handling all told constitutes a big part of the burdensome work and cost in the distribution of clay products, and anything that makes for less work and great efficiency in handling is deserving of attention. So it seems in order to give a little more attention to the possibilities of new ideas in unit quantity handling.

—The Clay Worker.

Sales of Clay in 1927

The quantity of clay sold by producers in the United States in 1927 amounted to 3,849,176 short tons, valued at \$13,697,159, or \$3.56 a ton, according to a statement made public by the United States Bureau of Mines, Department of Commerce. These figures show a decrease of 3 per cent in quantity and value compared with 1926. They represent only clay sold as clay or mined under royalty and do not include greater quantity of clay that was burned into clay products by the producers themselves from their own property.

The sales of kaolin, the clay that is used in making high-grade pottery and porcelain, as well as paper, oil cloth, and other products, and which is generally considered the highest grade of clay, amounted to 454,245 tons, valued at \$3,809,834, an increase of 5 per cent in quantity and 1 per cent in value as compared with 1926. The clay of largest quantity and value is fire clay. The sales of fire clay in 1927 were 2,699,761 tons. This was 4 per cent less than those of 1926, the year of largest sales. The value of the fire clay sold in 1927 was \$7,719,725, a decrease of 5 per cent as compared with 1926.

Clay Sold by Producers in the United States in 1926 and 1927.

Kind	1926		1927	
	Short-tons	Value	Short-tons	Value
Kaolin	432,215	\$ 3,771,568	454,245	\$ 3,809,834
Ball clay	112,195	867,500	119,763	913,976
Slip clay	8,644	45,959	6,137	32,264
Fire clay	2,819,346	8,119,323	2,699,761	7,719,725
Stoneware clay ..	84,002	185,288	98,355	203,648
Misc. clay	510,796	1,115,951	470,915	1,017,712
	3,967,198	\$14,105,589	3,849,176	\$13,697,159

—The Clay Worker.



SAFETY FIRST IN THE STEEL PLANT

Metals Section of Safety Congress

Members of the National Safety Council's Metals Section convened at a roll call luncheon, which was held on October 1 in the Waldorf-Astoria Hotel, New York City, immediately following the general meeting of delegates to the seventeenth annual safety congress.

The community singing at the luncheon was directed by N. V. B. Zeigler, personnel director of the U. S. Aluminum Company, New Kensington, Pa. There was an address by Dr. Charles Herbert Russ of Worcester, Mass., and reports of the various committee chairmen.

At the morning meeting on October 2, R. M. Roosevelt, vice president of the Eagle Picher Lead Company, New York City, discussed "Safety from the Viewpoint of Management." Dominic Samuels, foreman, Youngstown Sheet & Tube Company, Youngstown, Ohio, offered a paper, "Safety from the Viewpoint of Supervision."

Nelson H. Kyser, safety engineer, the Studebaker Corporation of America, South Bend, Ind., spoke on "The Correction of Unsafe Practices in Foundries," at the meeting session on October 3. Following the election of officers, L. A. Hartley, director, educational department, National Founders Association, led a discussion on "Developing a Safe Human Factor in Our Industries," and A. W. Colcord, M.D., plant surgeon, Clairton Works, Carnegie Steel Company, Clairton, Pa., opened a discussion on "The Placement of Men, or What the Surgeon Can Do."

Dr. L. W. Chaney, U. S. Bureau of Labor Statistics, Washington, spoke on "A Review of Accidents and Progress in the Steel Industry" at the morning meeting on October 4. "That the Foreman Is Responsible for Accidents that Occur in His Department," was a subject for debate in which J. A. Voss of the Central Alloy Steel Company, and Mike Grady, president, Stark Foreman's Club, Canton, Ohio, participated. John A. Oartel, chief of Safety Bureau, Carnegie Steel Company, Pittsburgh, presented some timely lantern slides.

Bethlehem Safety Prize

Under the company's 1928 accident prevention contest, the mines group won the first prize of \$1,000 for the best safety record made during the second quarter.

Film Shows Hazards of Carbon Monoxide

As a means of reducing the heavy annual death rate caused by that insidious and almost universal poison gas, carbon monoxide, the United States Bureau of Mines, Department of Commerce, has completed a one-reel educational motion picture film entitled, "Carbon Monoxide: The Unseen Danger." This film, prepared in co-operation with one of the large automobile manufacturing companies, shows vividly how this deadly gas may be encountered in workshop, garage and home, points out ways of preventing accumulations of the gas, and visualizes methods of reviving victims of the gas.

This educational motion picture film is now available for showing by schools, churches, clubs, civic and business organizations, miners' local unions and other bodies. Copies may be obtained from the Pittsburgh Experiment Station of the United States Bureau of Mines, Pittsburgh, Pa. No charge is made for the use of the film, but the exhibitor is requested to pay transportation charges.



Dominic Samuels, whose paper before the Metals Section of the National Safety Council appears on another page in this issue, is foreman of the tube galvanizing department, Youngstown Sheet and Tube Company, Youngstown, Ohio.

"Getting Facts About Accidents"

This is the second of a series of publications issued by the Policyholders' Service Bureau of the Metropolitan Life Insurance Company, presenting the basic principles of successful industrial safety work.

This booklet, addressed primarily to the chief operating official, outlines current industrial practice in obtaining and using accident facts as a means of promoting plant safety. It presents convincing evidence of the value of accurate knowledge, concerning how and where accidents occur, on the part of those executives charged with responsibility for keeping informed of the weak spots in the organization and of this cause of excessive production costs. Accident forms are provided, which have been found helpful in recording the necessary facts and making them available for study. There is also given a description of methods by which this information may be put to maximum preventive use.

Copies of "Getting Facts About Accidents" may be obtained by those interested in the subject of accident statistics by addressing the Policyholders' Service Bureau of the Metropolitan Life Insurance Company.